

5 DYNAMIC SIMULATION

5.1 DYNAMIC SIMULATION CASE

Dynamic model was built in order to predict the operation variables such as temperature, pressure and recycle rate of propane refrigerating compressor unit according to the vaporizing rate from propane storage tanks when the operation mode are changing from hold mode at 52 °C ambient temperature to load mode at 12 °C of propane storage system.

Table 5.1.1 shows Propane BOG condensing duty for each case.

Table 5.1.1 Propane BOG condensing duty for each case

CASE	1	2	3	4
	Max boil off at max ambient	Max boil off at min ambient	Min boil off at max ambient	Min boil off at min ambient
BOG quantity (kg/hr)	19,642	12,265	9,312	3,959
BOG Composition				
Ethane (mol%)	13.06	12.64	12.27	12.00
Propane (mol%)	86.86	87.28	87.65	87.92
i-Butane (mol%)	0.07	0.07	0.07	0.07
n-Butane (mol%)	0.01	0.01	0.01	0.01
BOG Condensing duty (KW)	2,748	1,701	1,317	556

(Based on page 22 of 26 DOCUMENT NO. 1718-0027)

5.2 SIMULATION PFD

Figure 5.2.1 shows the HYSYS PFD model. Two identical compressor systems are displayed as each subflowsheets to simplify the PFD. These systems include the suction drum, compressor and desuperheater.

Figure 5.2.1 Overall PFD

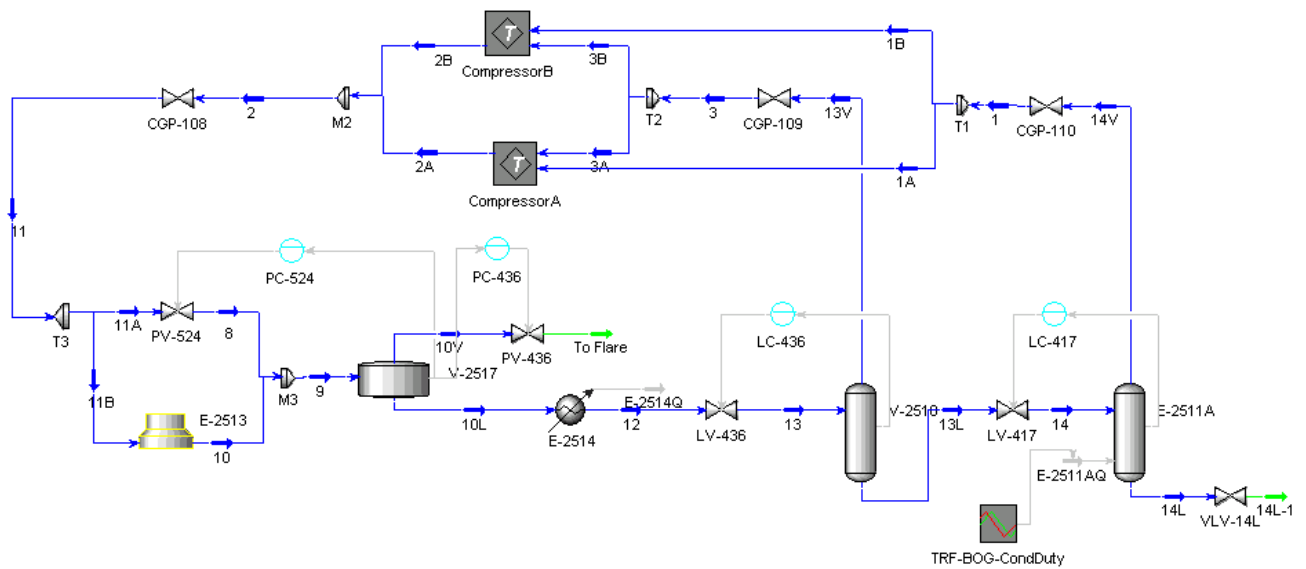


Figure 5.2.2 Subflowsheet of K-2509A

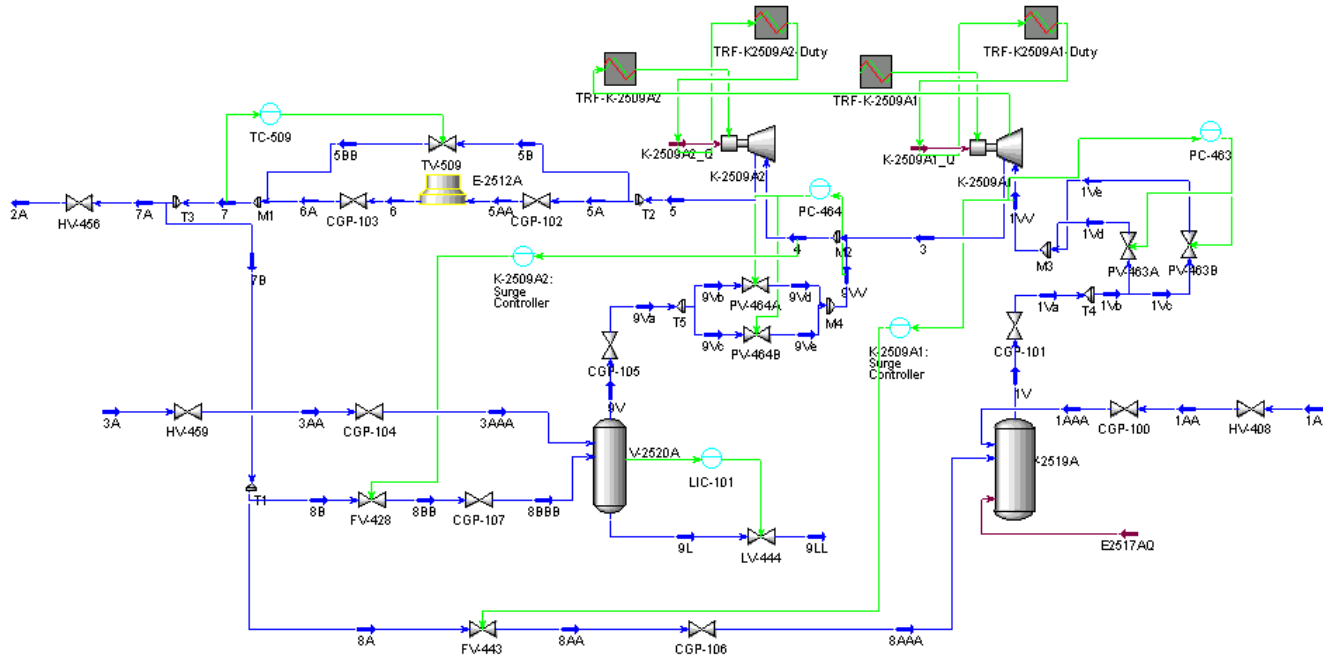


Figure 5.2.3 Subflowsheet of K-2509B

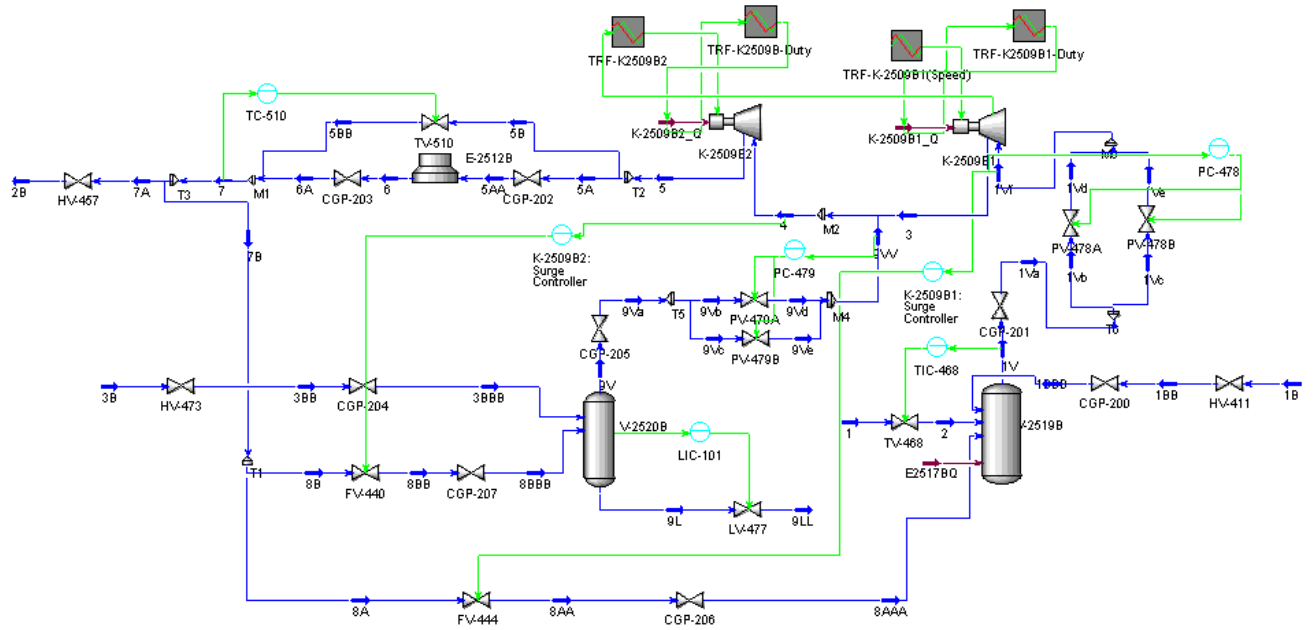


Figure 5.2.4 Pressure profile of K-2509B flow sheet at the full recycle mode

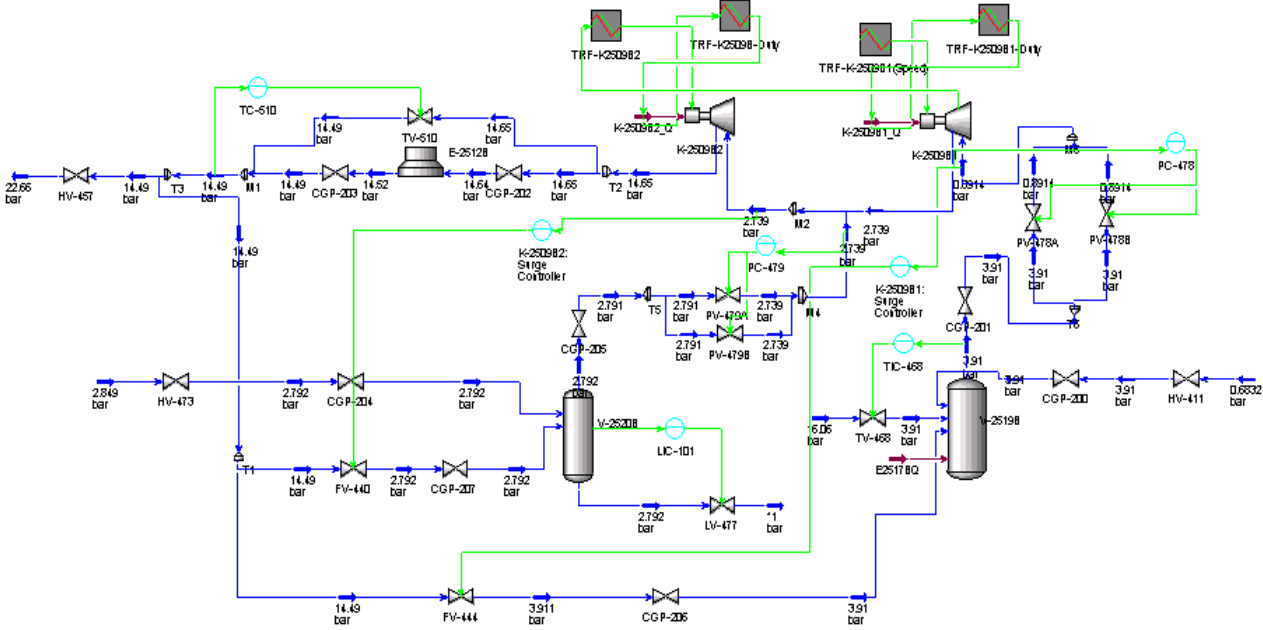
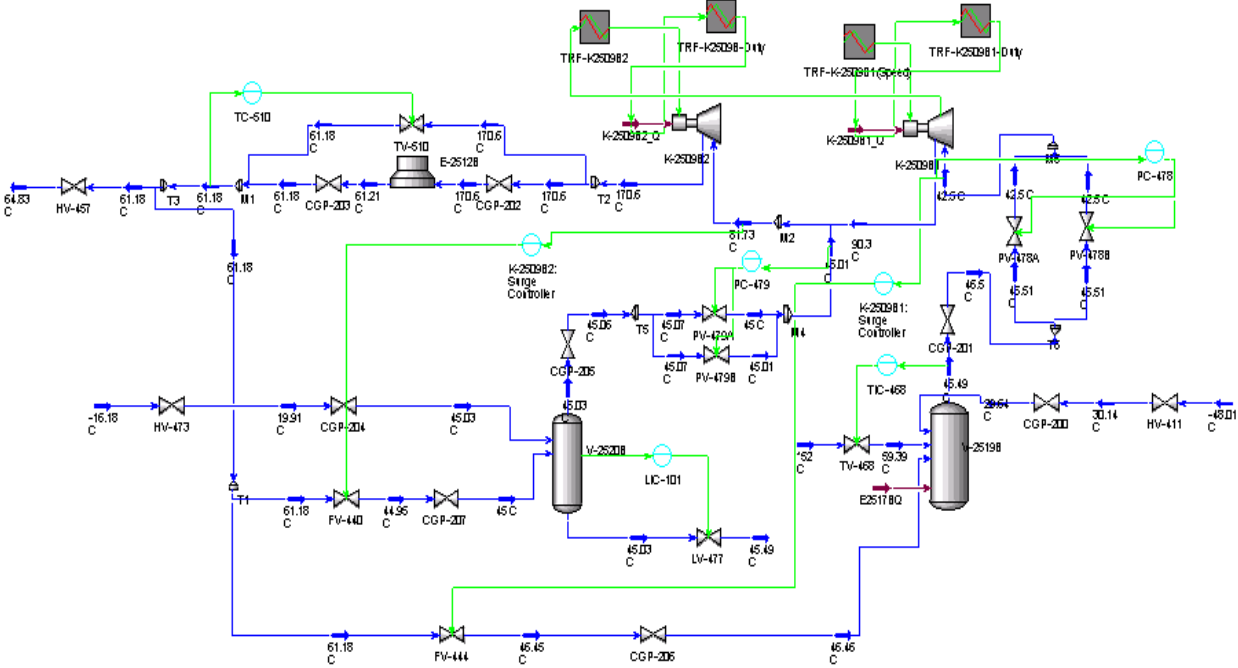


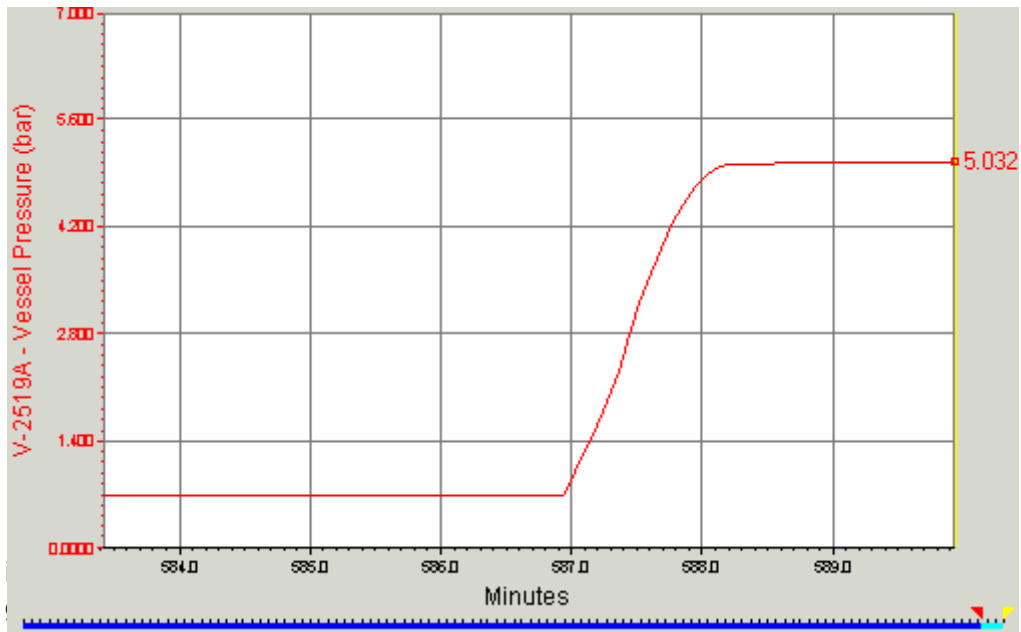
Figure 5.2.5 Temperature profile of K-2509B flow sheet at the full recycle mode



5.3 SETTLE OUT PRESSURE

Dynamic model was built in order to see the settle out pressure of propane refrigeration compressor unit when the compressor shutdowns in 1 minute and HV-408, HV-456 and HV-459 are closed instantaneously.

Figure 5.3.1 Pressure profile at the V-2519A



U
Figure 5.3.2 Pressure profile at the V-2520A

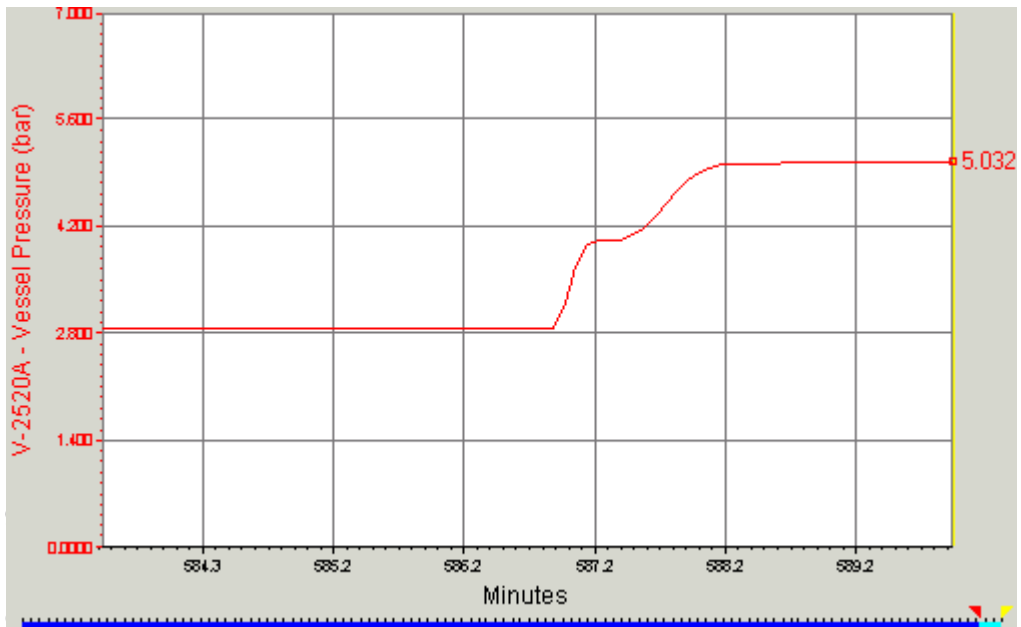


Figure 5.3.3 Temperature profile at V-2519A

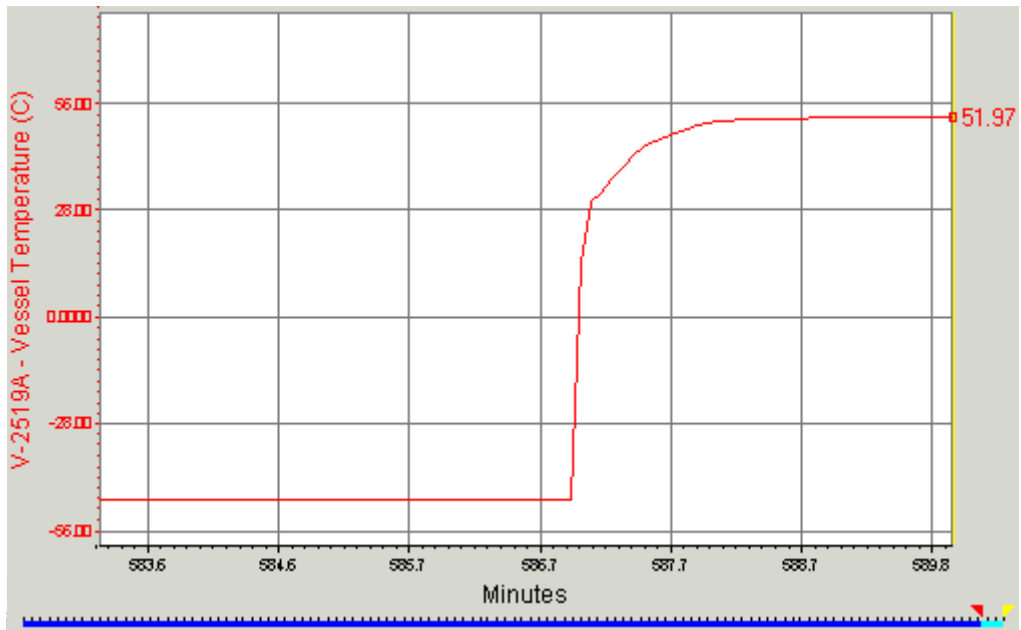
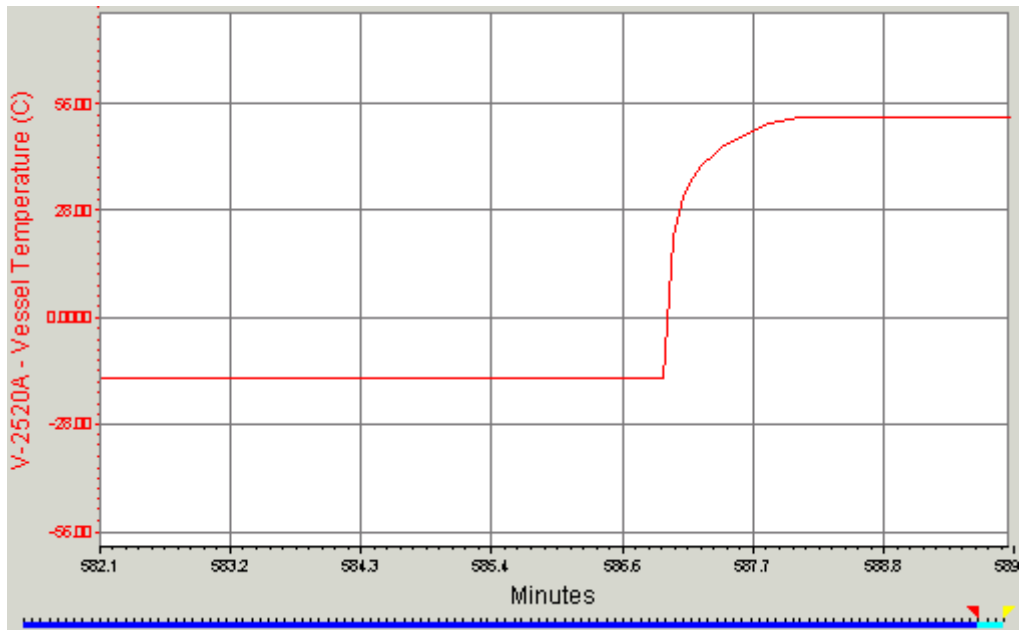


Figure 5.3.4 Temperature profile at V-2520A



5.4 START-UP DUTY COMPRESSOR FROM SETTLE OUT PRESSURE.

The procedure of start-up of the compressor is as follows

- Set the suction throttling valves as full close
- Compressor speed up with the anti-surge valve full open
- Set the anti-surge controller mode from Manual to Auto
- Open the suction throttling valves as full open

The results of the start-up of the compressor from the settling conditions with this procedure are shown as followings. It shows that the compressor is going to the full recycle mode.

Figure 5.4.1 Pressure profile at V-2519 during start-up of K-2509A

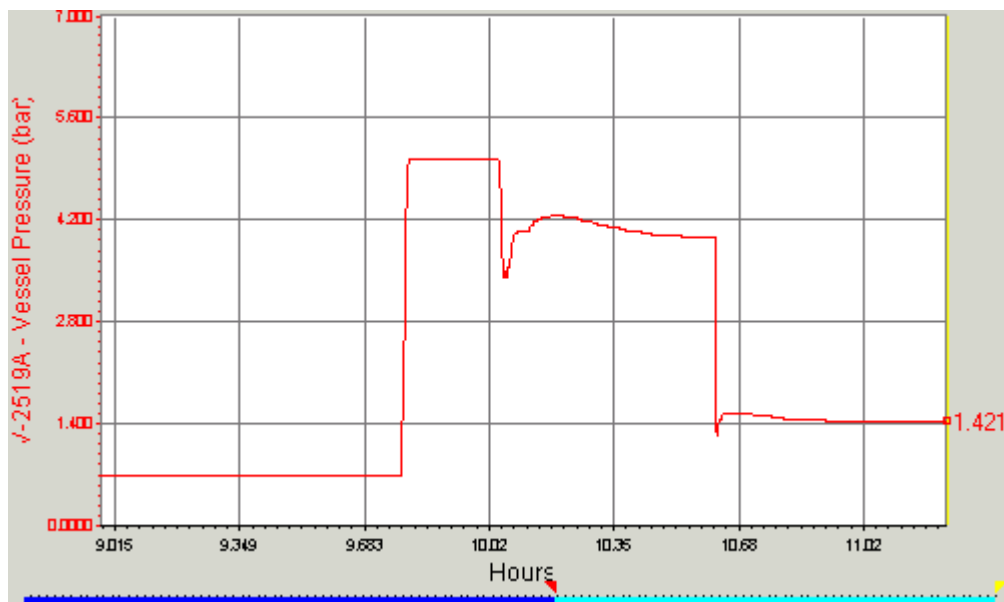
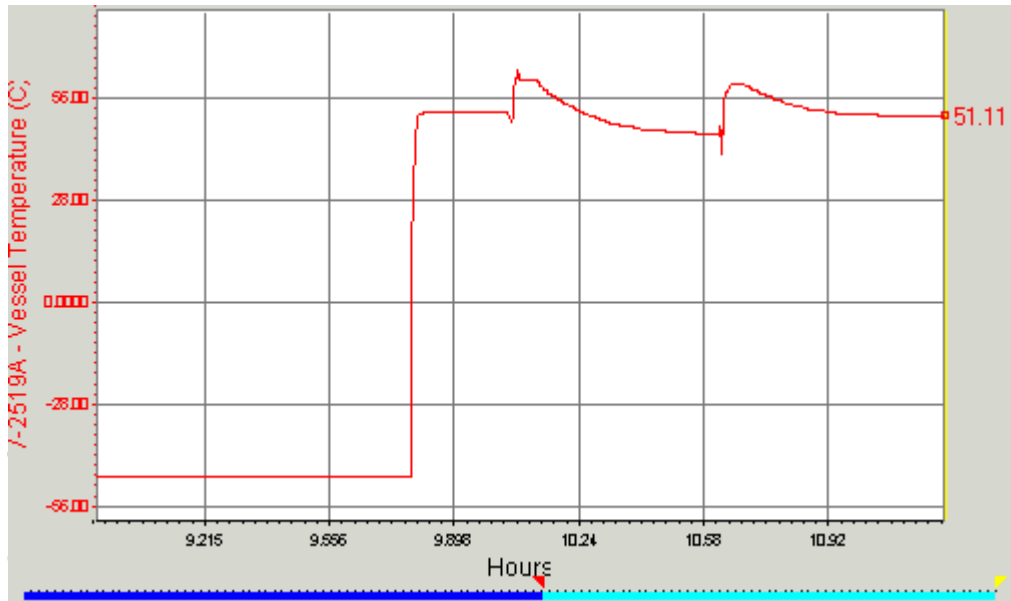


Figure 5.4.2 Temperature profile at V-2519 during start-up of K-2509A



5.4.3 Pressure profile at V-2520 during start-up of K-2509A

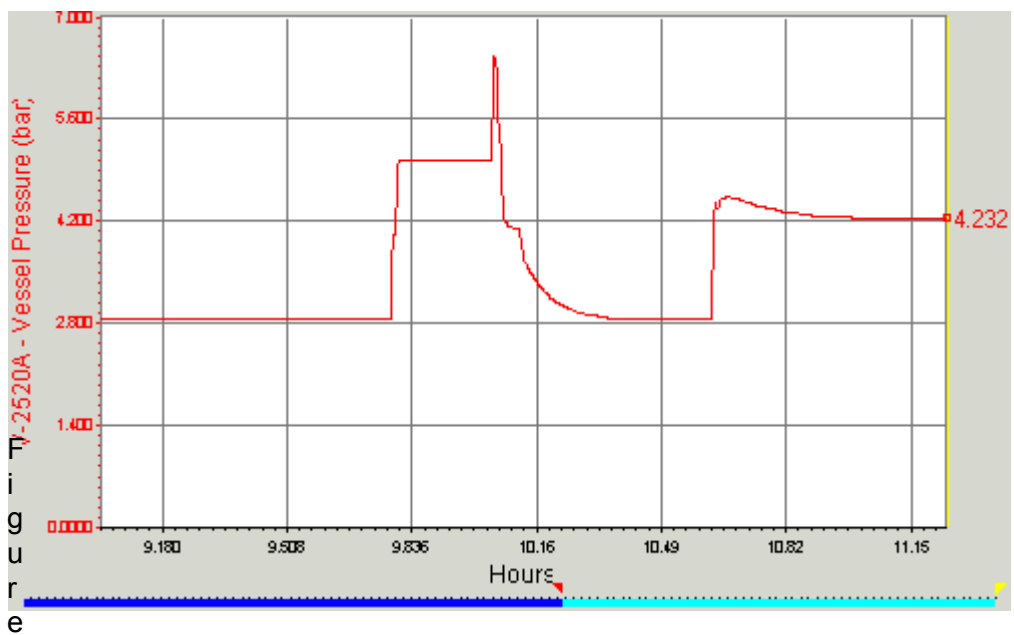


Figure 5.4.4 Temperature profile at V-2520 during start-up of K-2509A

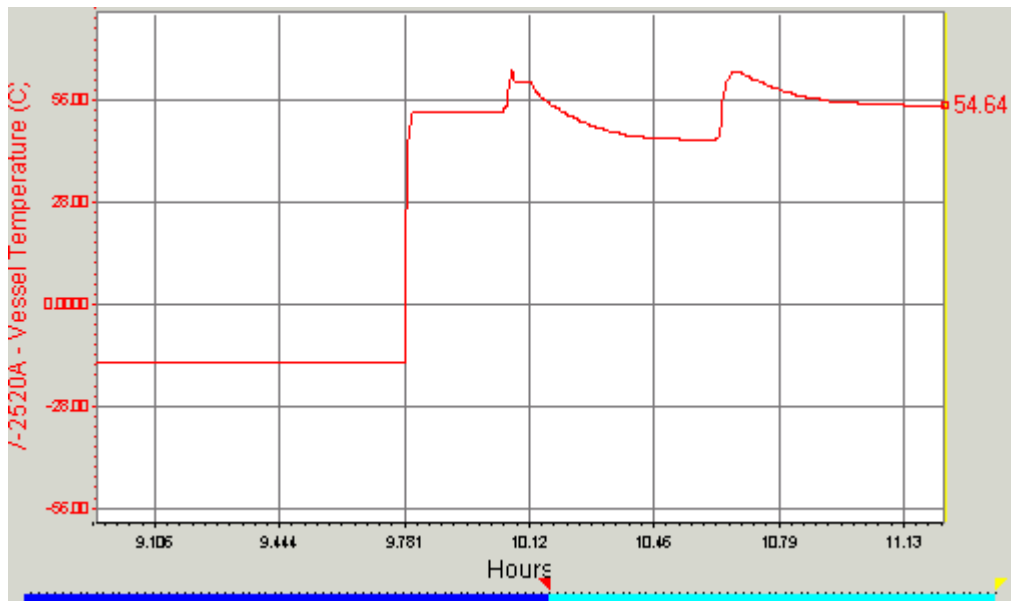
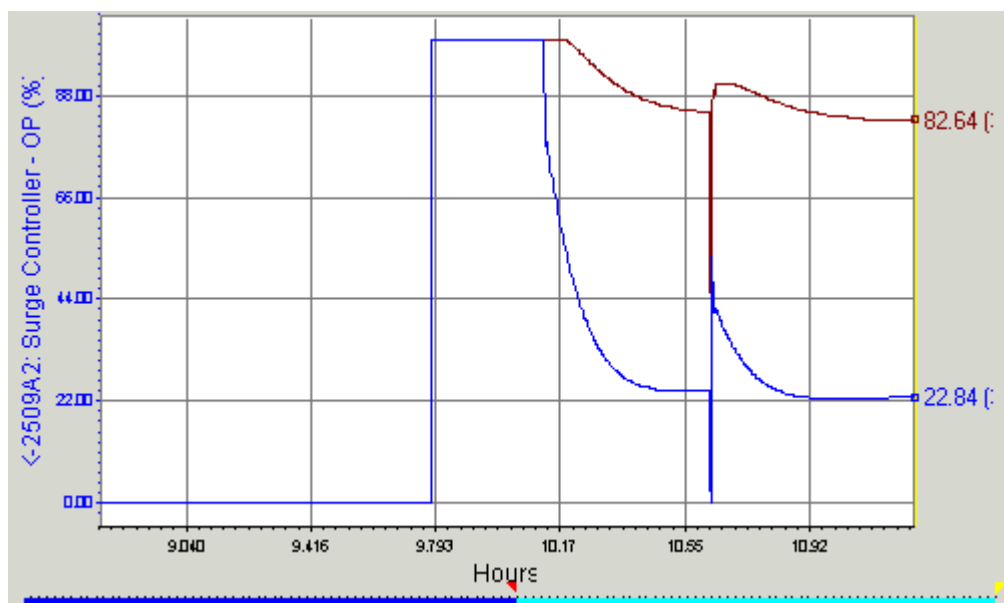


Figure 5.4.5 Opening % profile of the anti-surge valve for 1st and 2nd stage



5.5 LOAD TRANSFER FROM DUTY TO STAND-BY COMPRESSOR

While the compressor K-2509A is on service, the stand-by compressor K-2509B is started up and gone to the full recycle mode. Load transfer from K-2509A to K-2509B can occur by closing the block valves in the K-2509A system after opening all the blocked valves in the K-2509B system. The results of this load transfer case are shown as follows.

Figure 5.5.1 Pressure profile at the discharge of 2nd stage during the load transfer

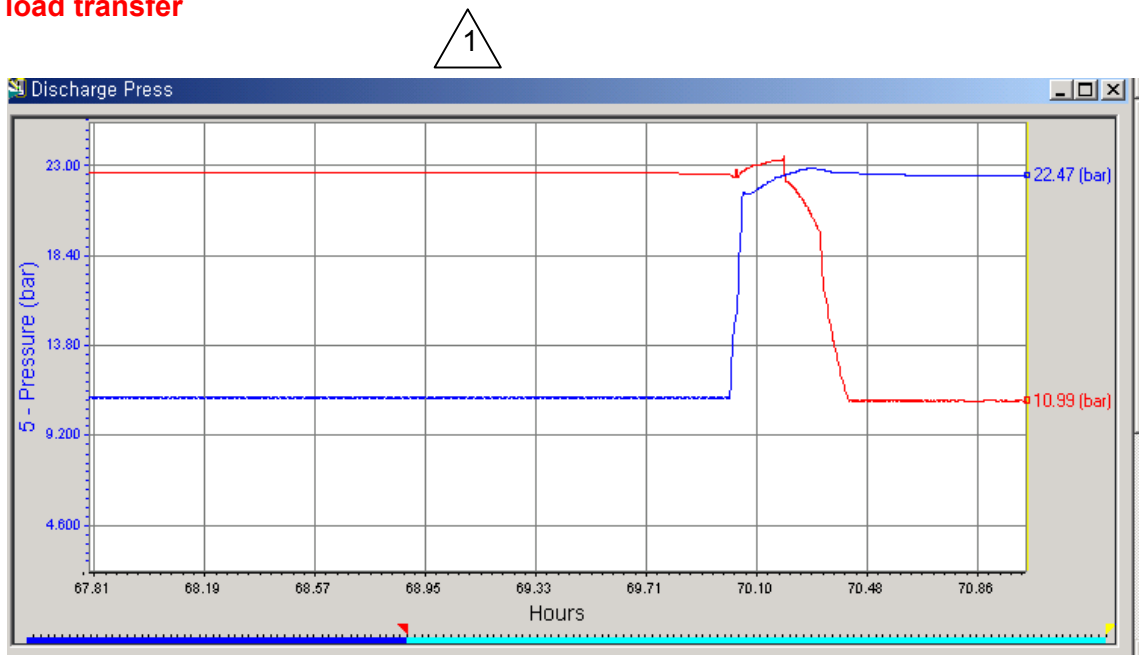




Figure 5.5.2 Temperature profile at the discharge of 2nd stage during the load transfer

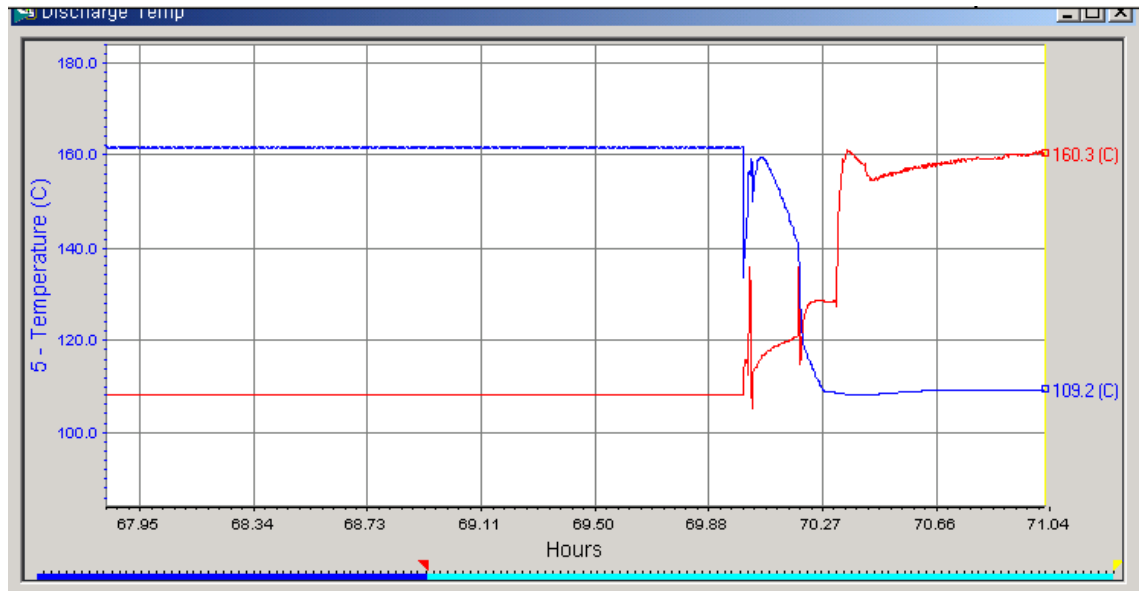


Figure 5.5.3 Pressure profile at V-2519 during the load transfer

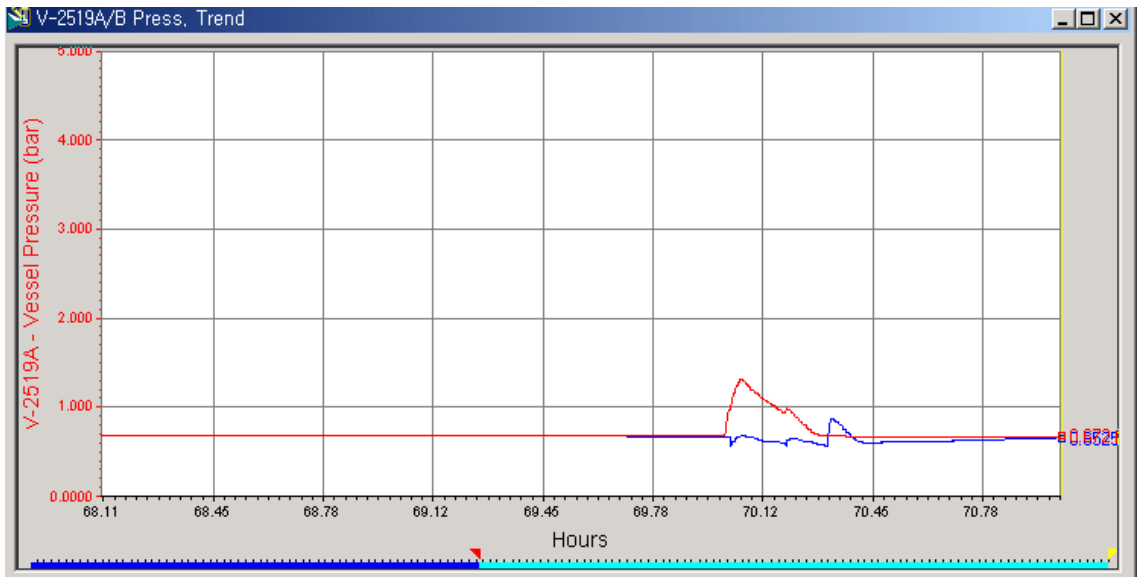


Figure 5.5.4 Temperature profile at V-2519 during the load transfer

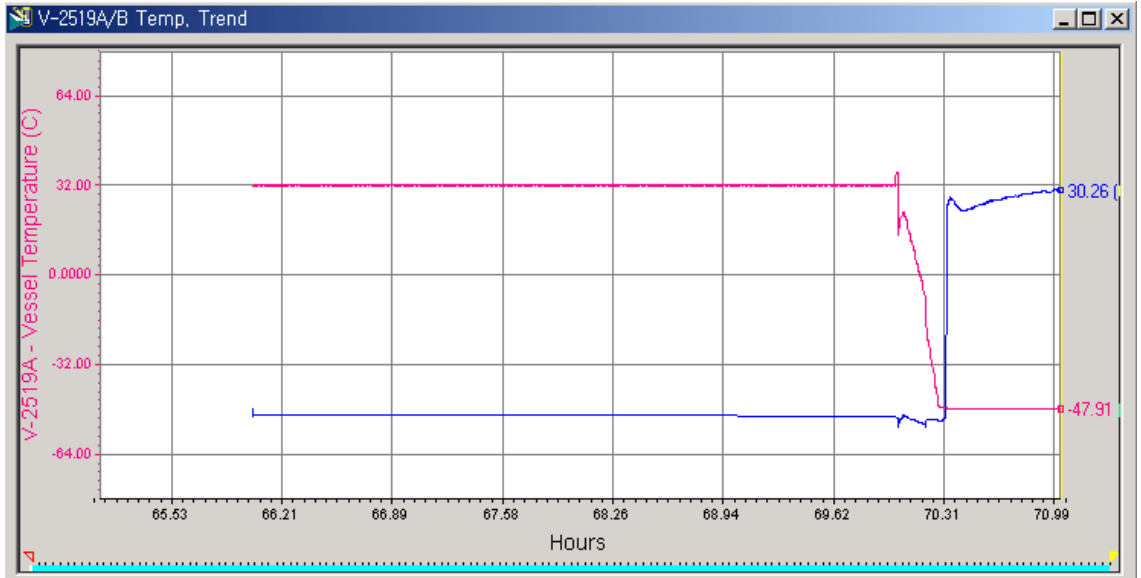


Figure 5.5.5 Pressure profile at V-2520 during the load transfer

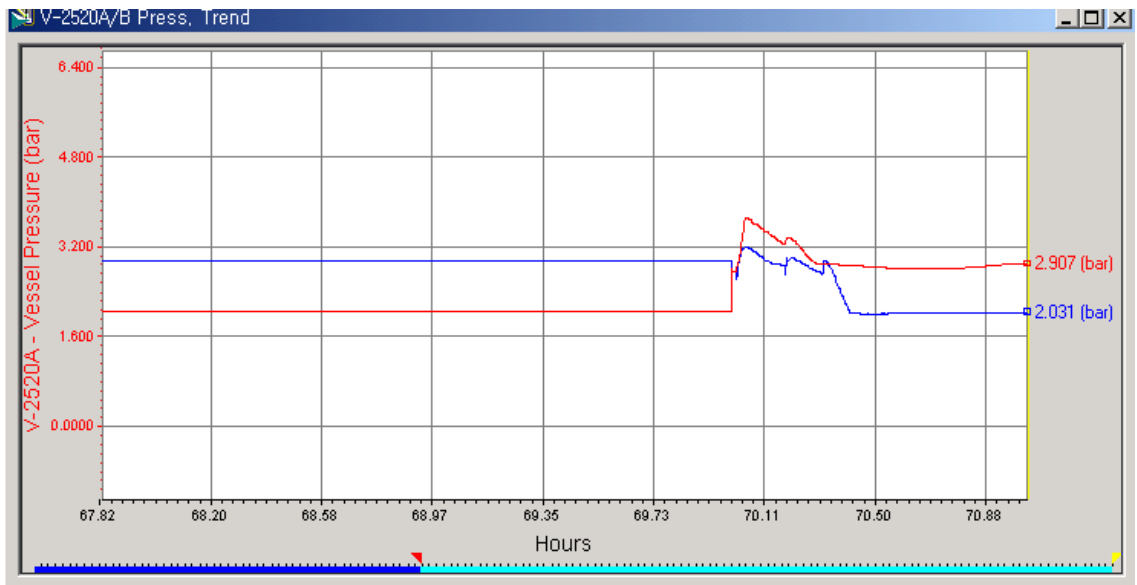


Figure 5.5.6 Temperature profile at V-2520 during the load transfer

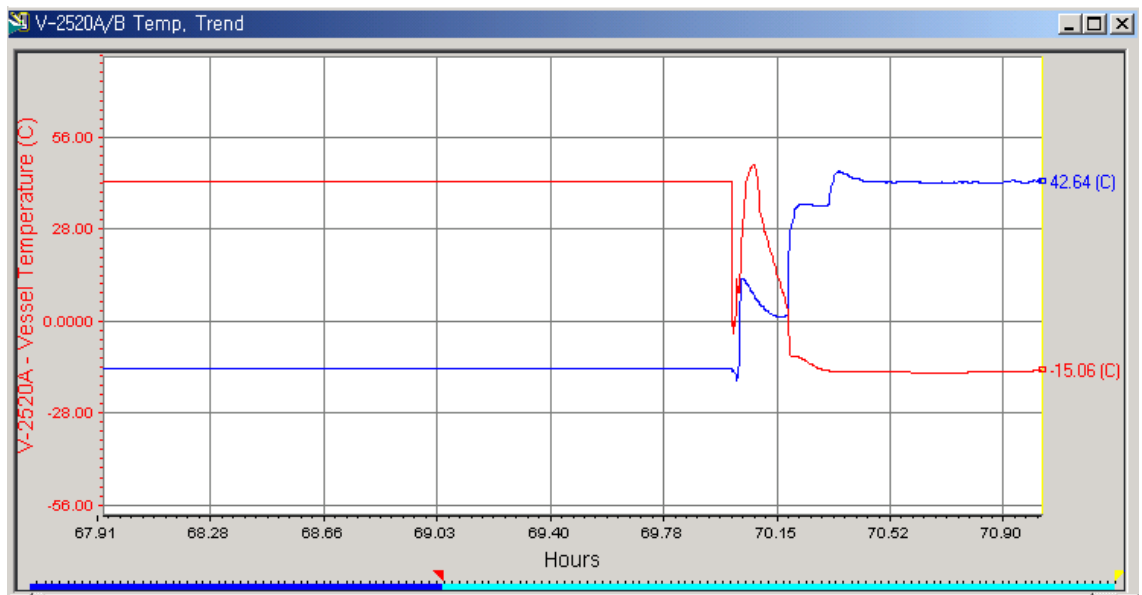


Figure 5.5.7 Opening % profile of the anti-surge valve during the load transfer

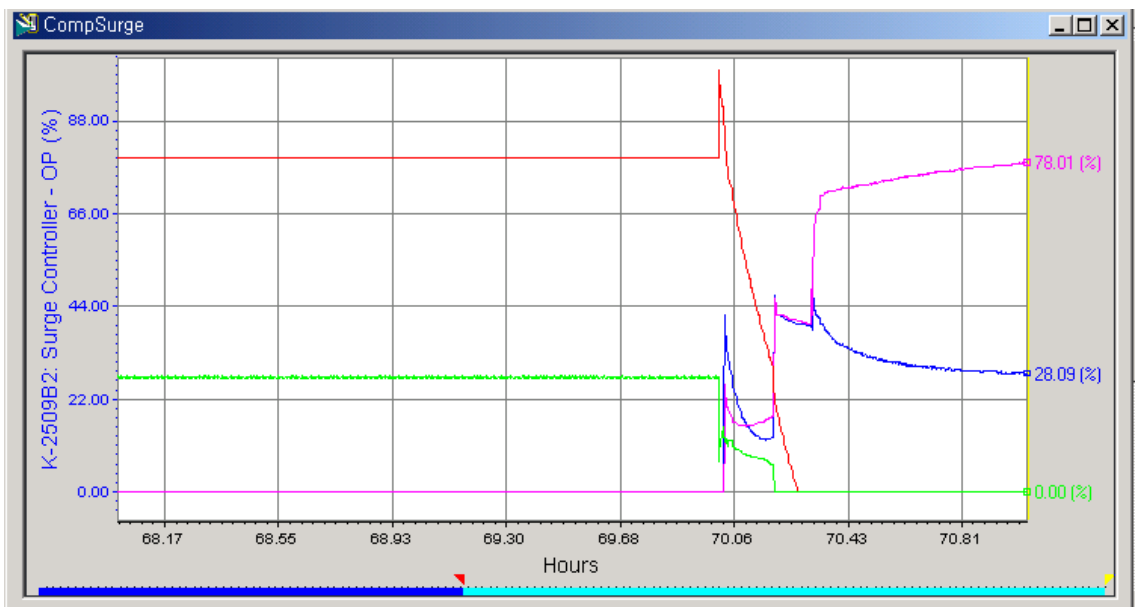


Figure 5.5.8 Duty change profile during the load transfer 1

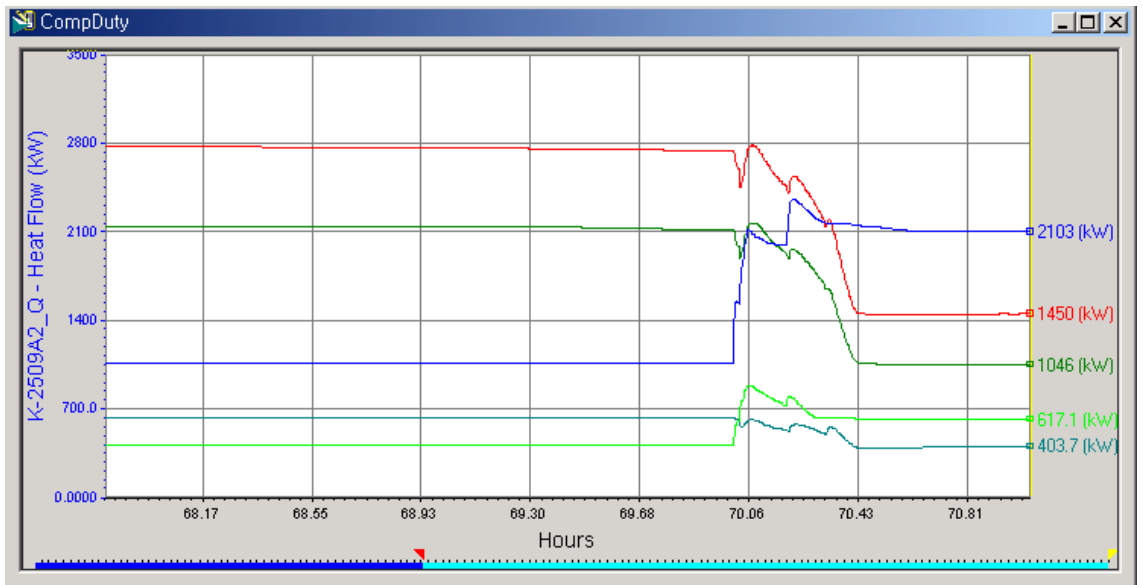
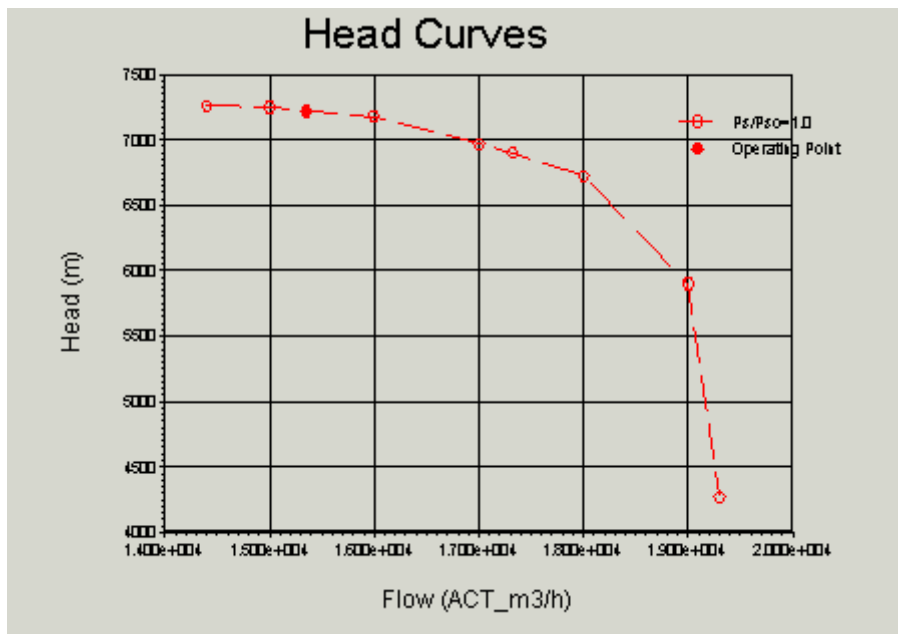
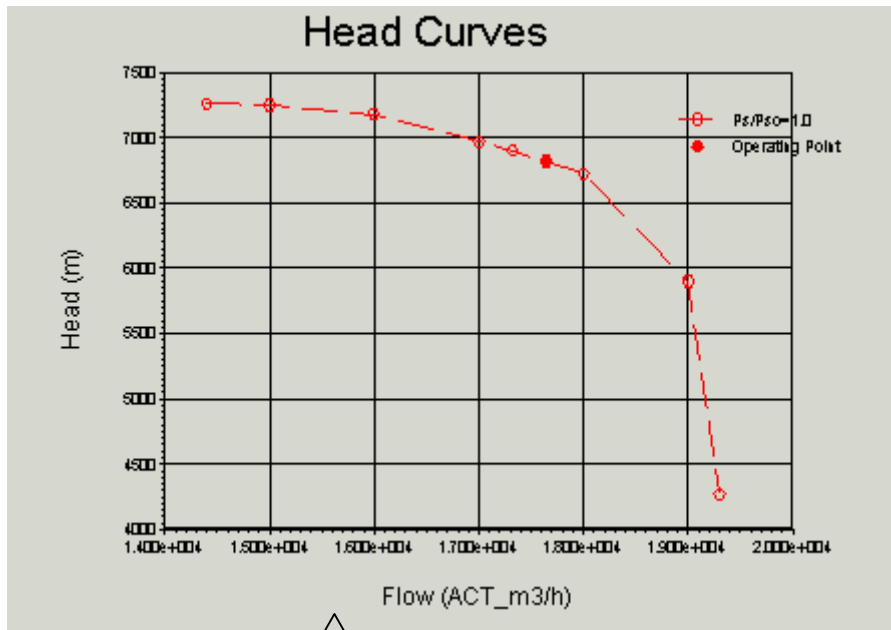


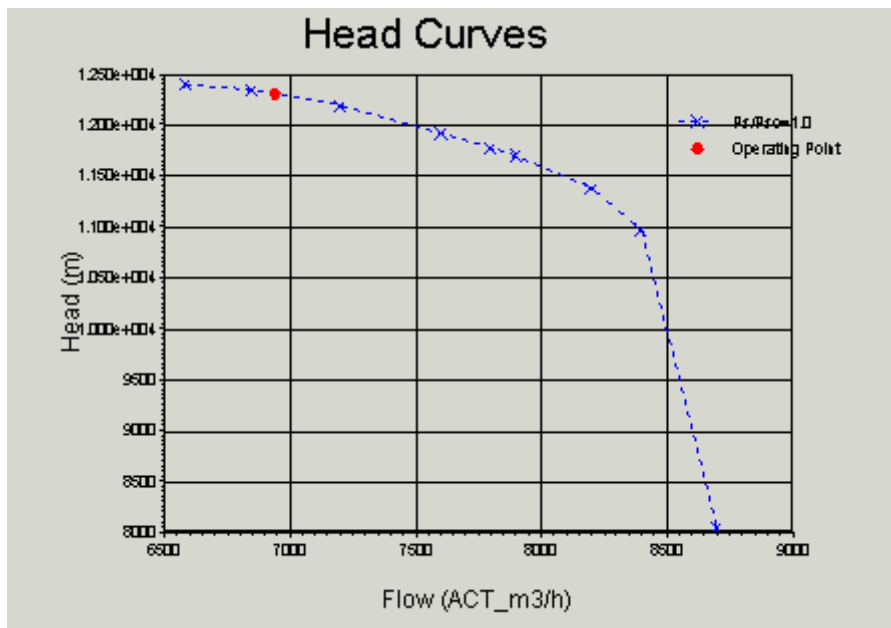
Figure 5.5.9 1st Stage Operating Point in K-2509A(on service) and K-2509B (recycle) 1



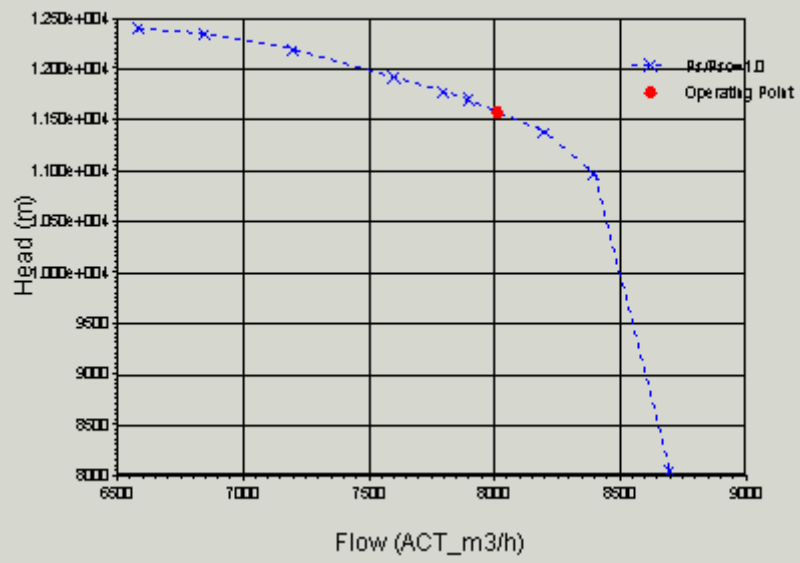


1

Figure 5.5.10 2nd Stage Operating Point in K-2509A(on service) and K-2509B (recycle)



Head Curves



5.6 CASE STUDIES FOR EACH LOAD CHANGES

The load of the refrigeration compressor K-2509A/B will be changed by the different Propane BOG rate from the storage tanks for each case as shown in the Table 5.1.1.

The behavior and operating conditions for each case are shown as follows. The base mode is the 52 °C holding mode (maximum boil-off at maximum ambient temperature) which treats condensing duty of 2748 KW.

5.6.1 MAXIMUM BOIL-OFF AT MAXIMUM AMBIENT TEMPERATURE (52 °C, BASE).

Figure 5.6.1 Pressure profile of the refrigerating system at the base mode

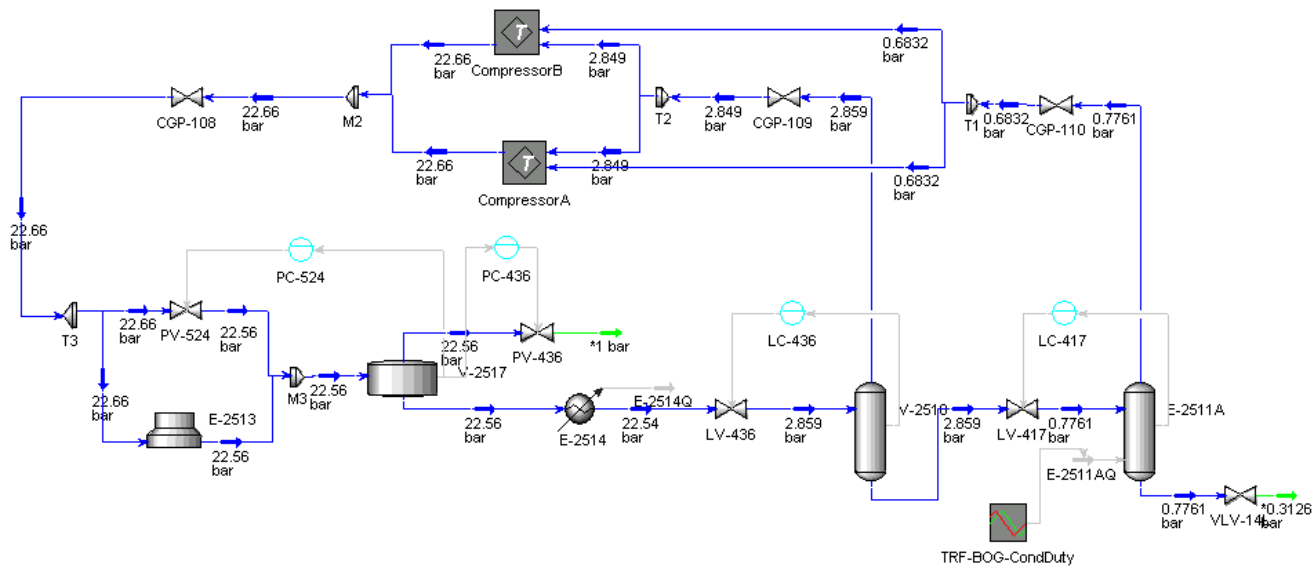


Figure 5.6.2 Temperature profile of the refrigerating system at the base mode

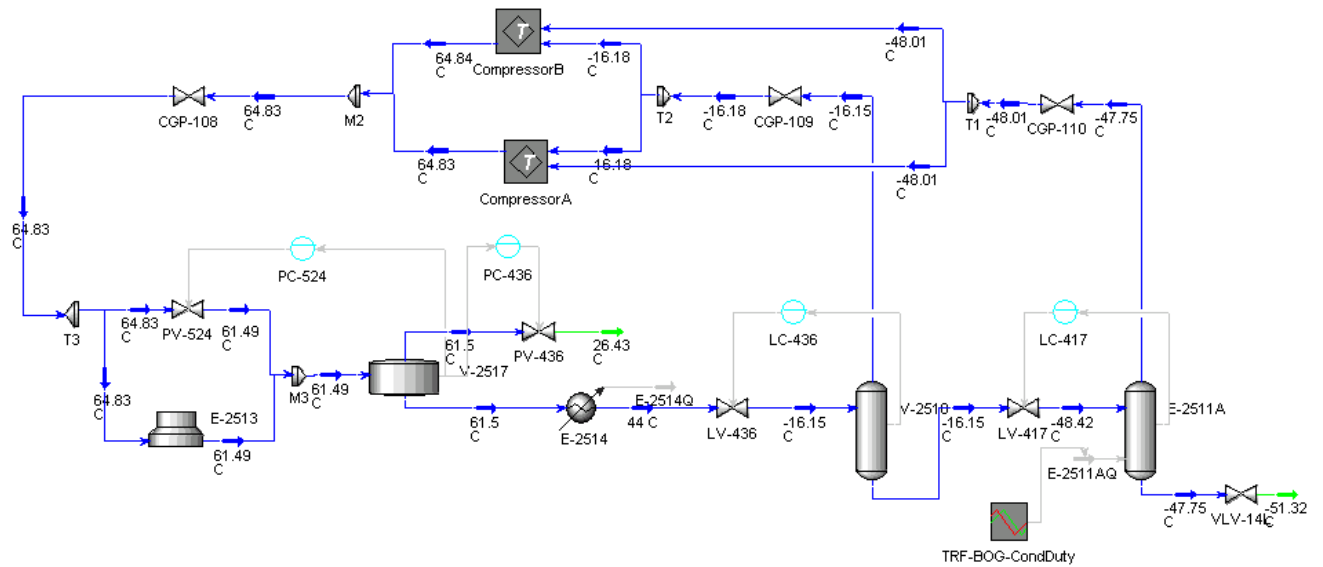
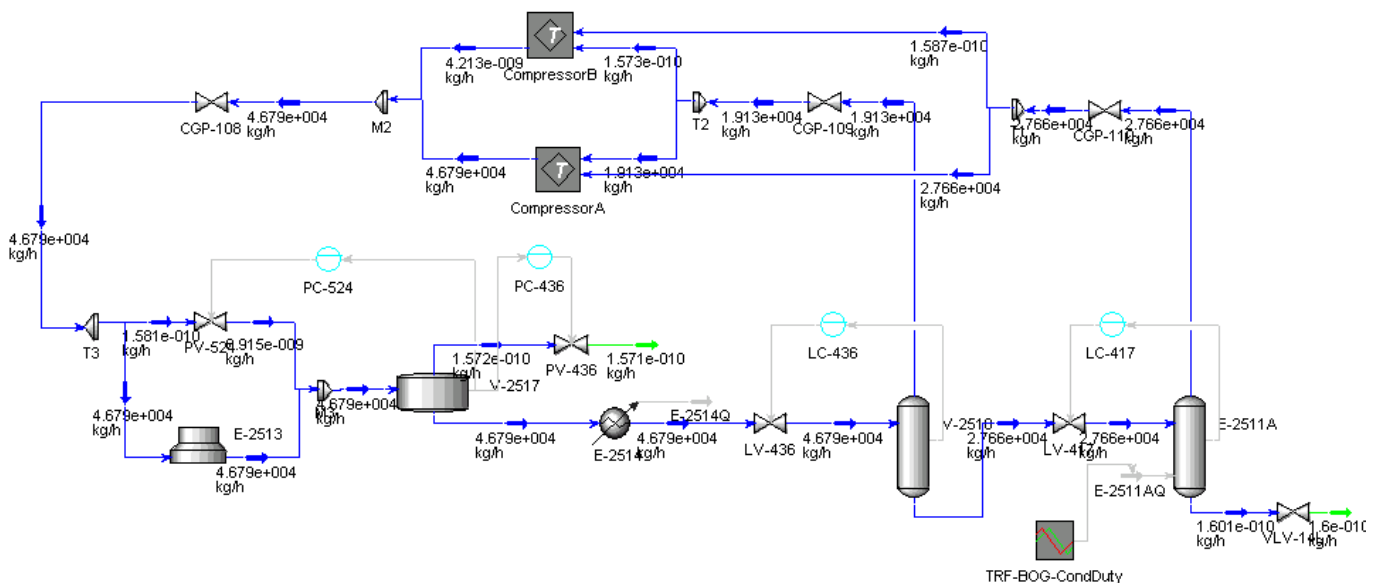


Figure 5.6.3 Mass flowrate profile of the refrigerating system at the base mode



5.6.2 MAXIMUM BOIL-OFF AT MINIMUM AMBIENT TEMPERATURE (12 °C, CASE 2).

BOG condensing duty changes from 2748 KW to 1701 KW. The behaviors of the refrigerating compressor system in this case are shown as follows. There is no meaning for the transition time of the change from 52 °C to 12 °C since it is a seasonal change, but this is just for examining the operating conditions.

Figure 5.6.3 Pressure profile at the discharge of 2nd stage at the case 2.

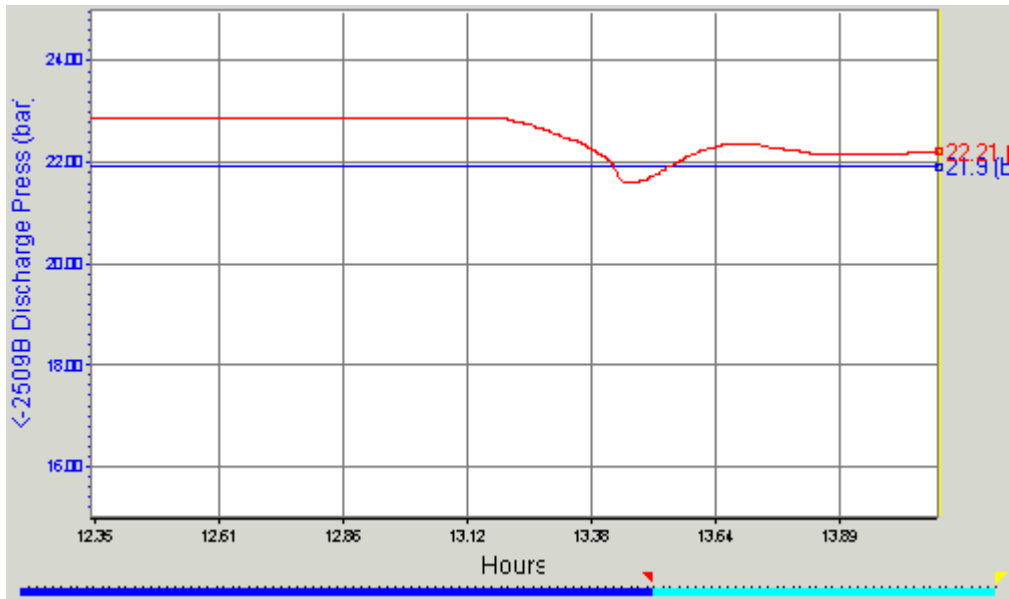


Figure 5.6.4 Temperature profile at the discharge of 2nd stage at the case 2.

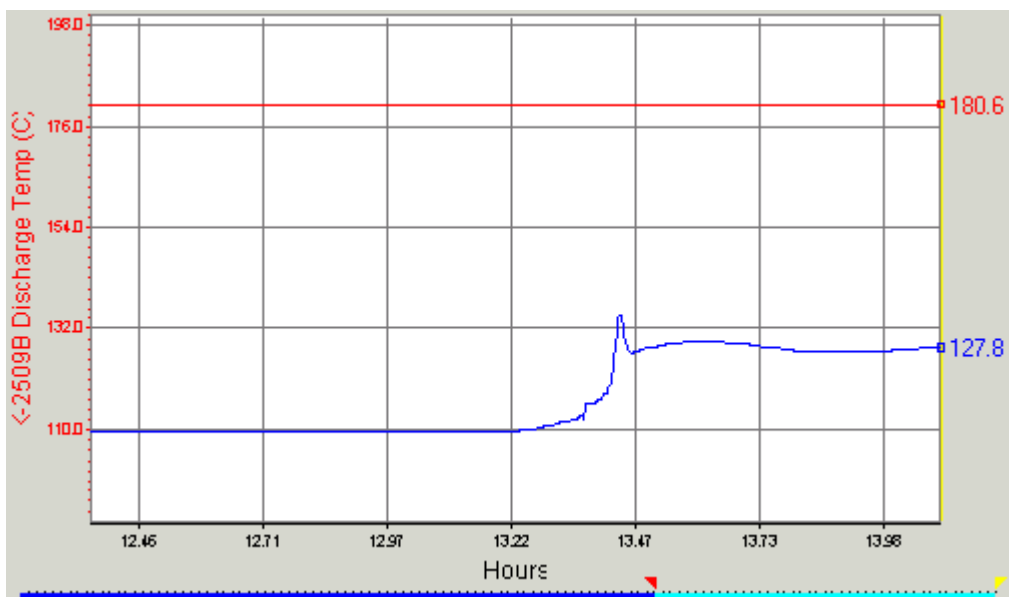


Figure 5.6.5 Pressure profile at V-2519 at the case 2.

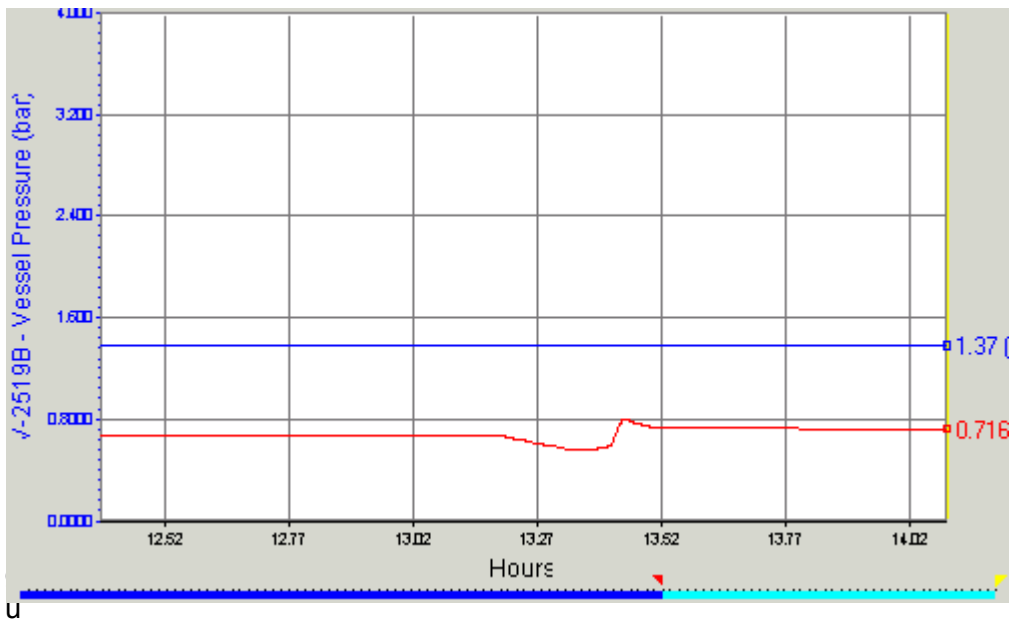


Figure 5.6.6 Temperature profile at V-2519 at the case 2.

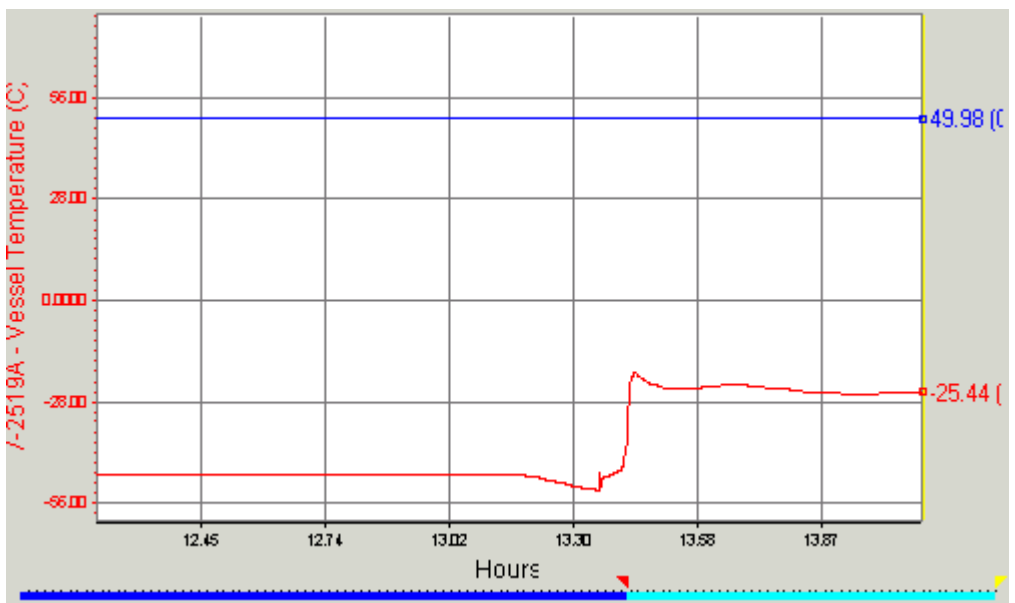


Figure 5.6.7 Pressure profile at V-2520 at the case 2.

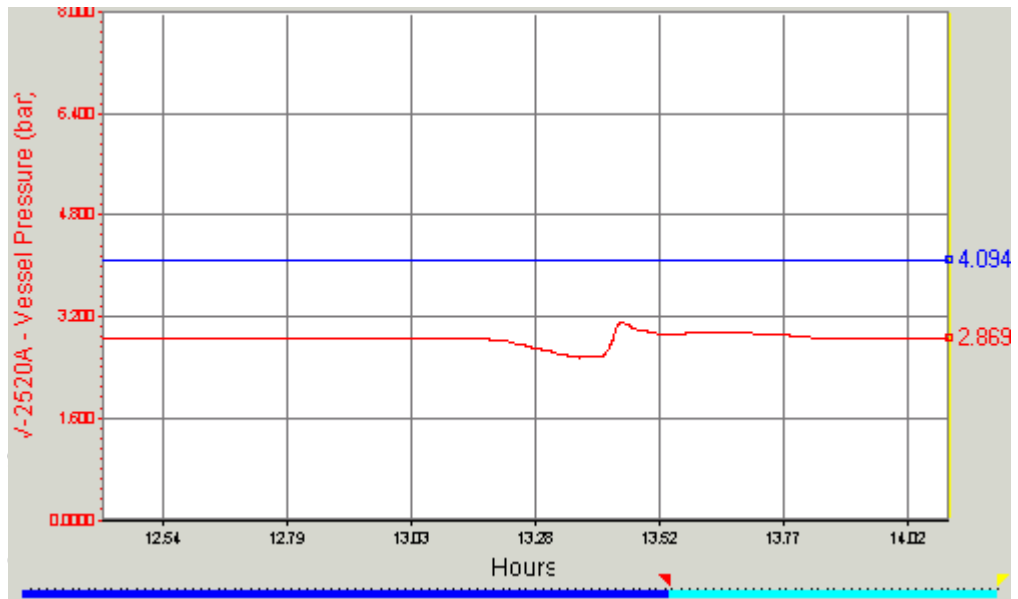


Figure 5.6.8 Temperature profile at V-2520 at the case 2.

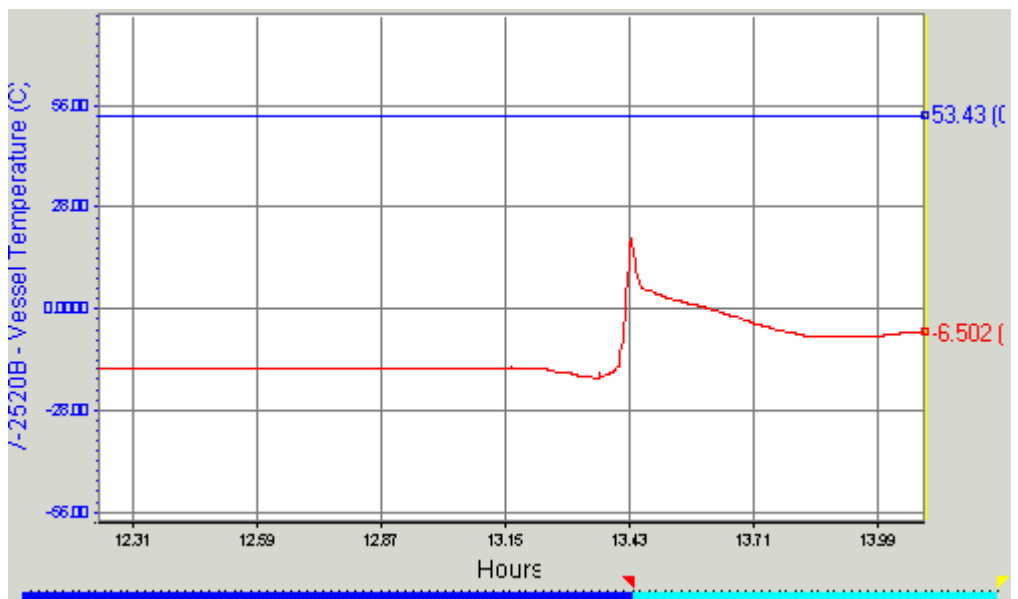


Figure 5.6.9 Opening % profile of the anti-surge valve for 1st and 2nd stage

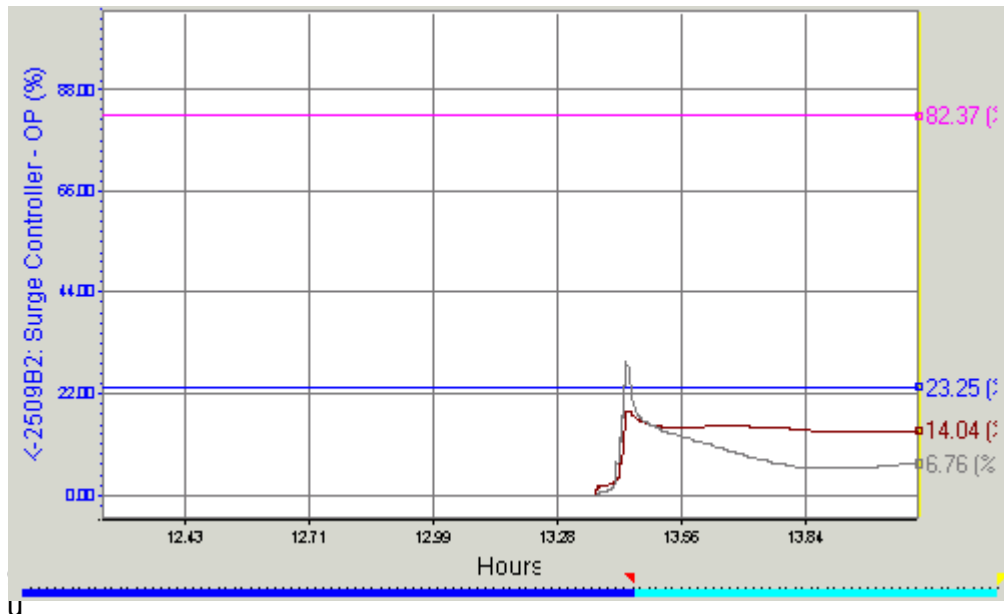


Figure 5.6.10 Pressure profile of the refrigerating system at the case 2.

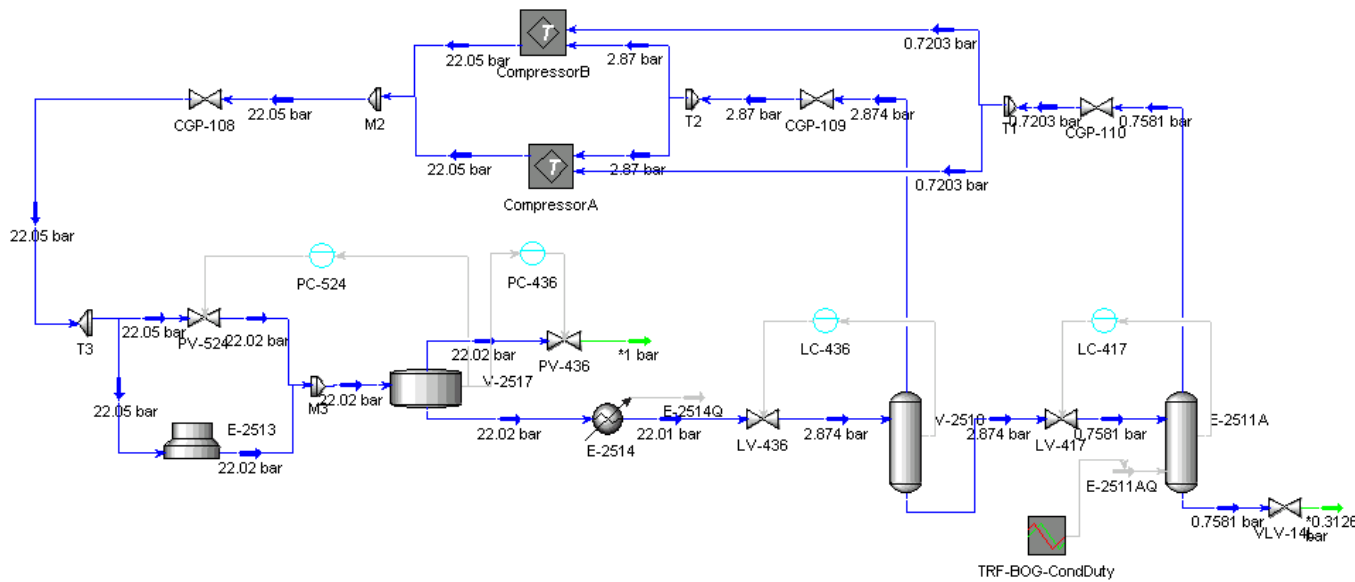


Figure 5.6.11 Temperature profile of the refrigerating system at the case 2.

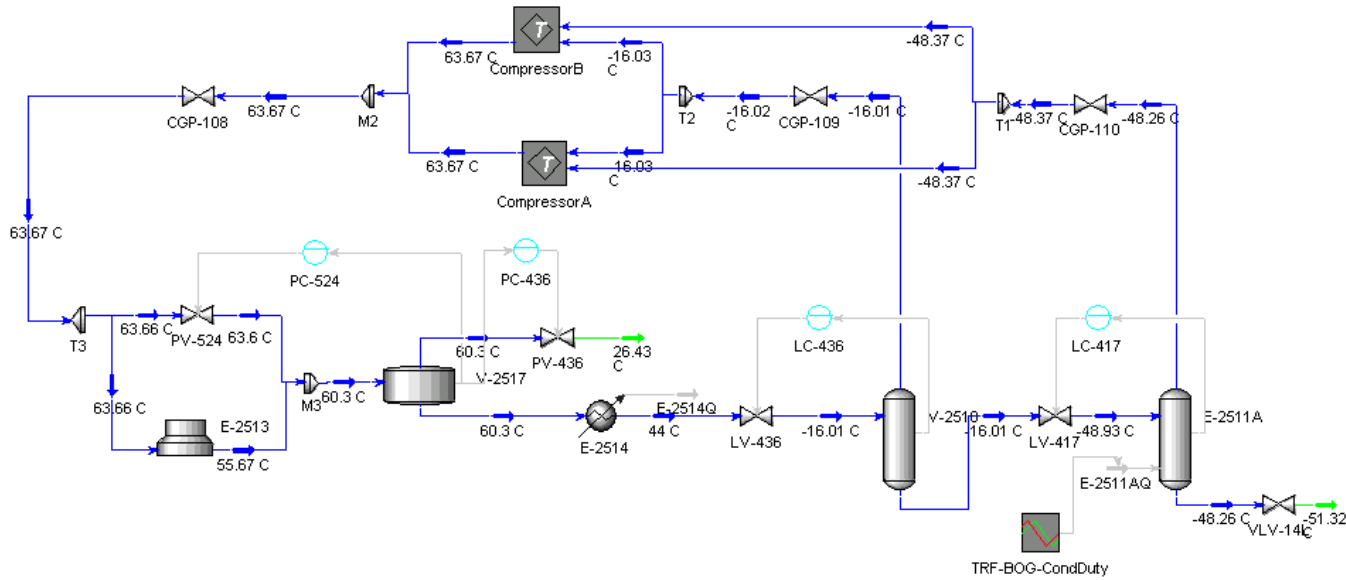
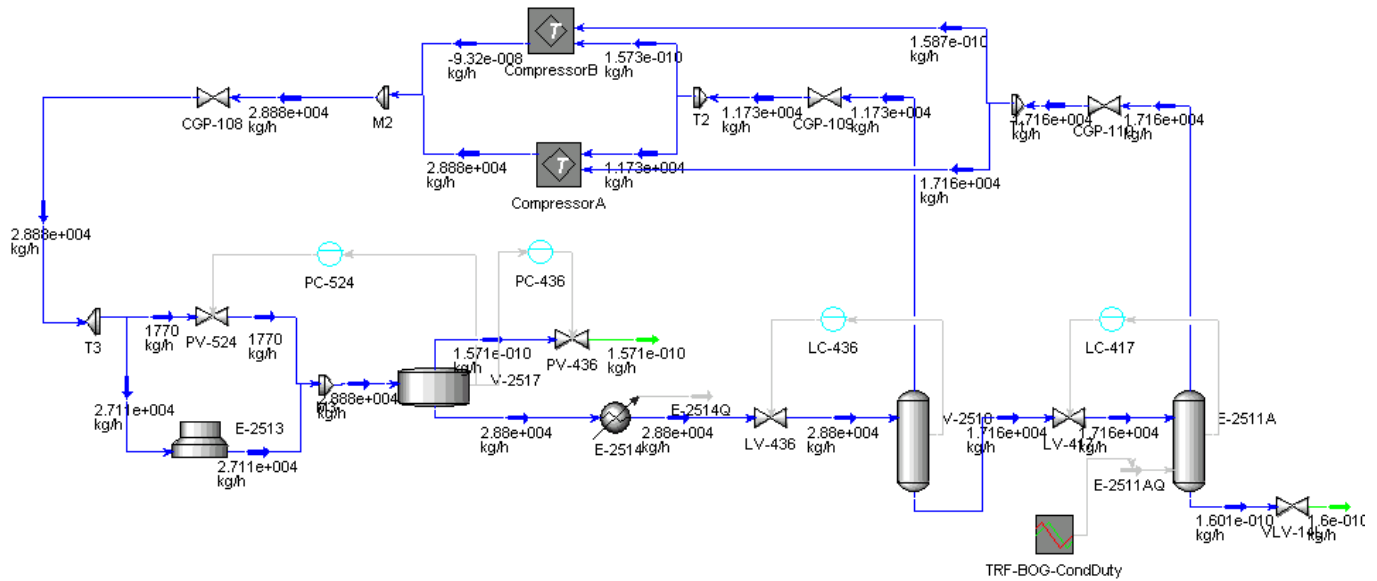


Figure 5.6.12 Mass flowrate profile of the refrigerating system at the case 2.



5.6.3 MINIMUM BOIL OFF AT MAXIMUM AMBIENT TEMPERATURE (52 °C, CASE 3).

BOG condensing duty changes from 2748 KW to 1317 KW. The behaviors of the refrigerating compressor system in this case are shown as follows.

Figure 5.6.13 Pressure profile at the discharge of 2nd stage at the case 3.

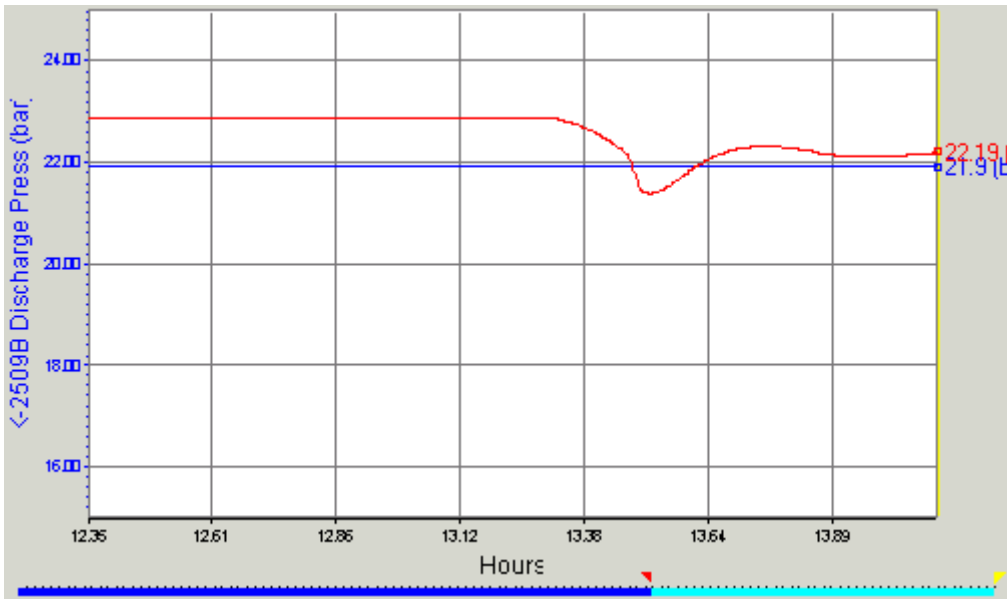


Figure 5.6.14 Temperature profile at the discharge of 2nd stage at the case 3.

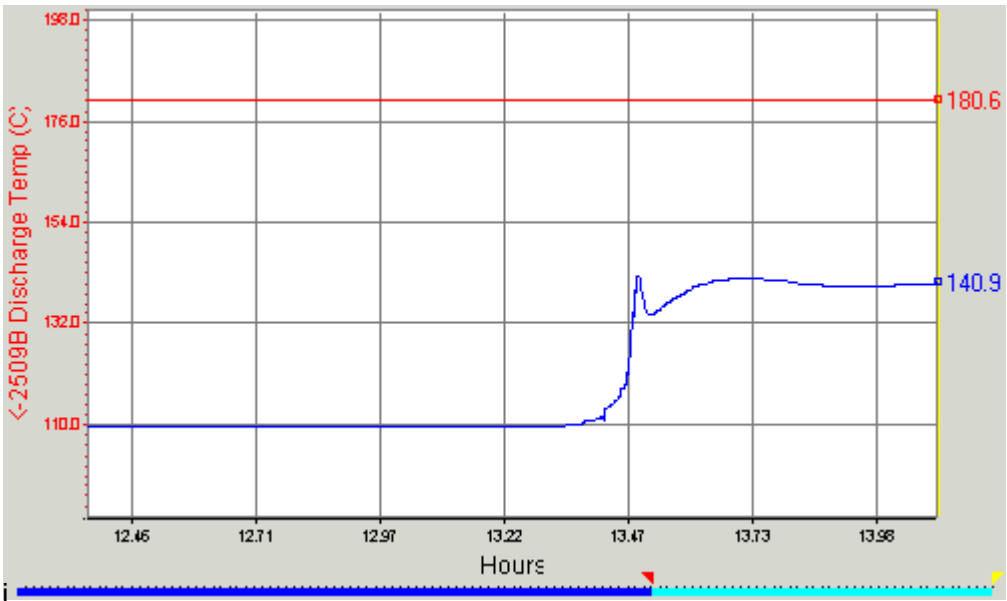
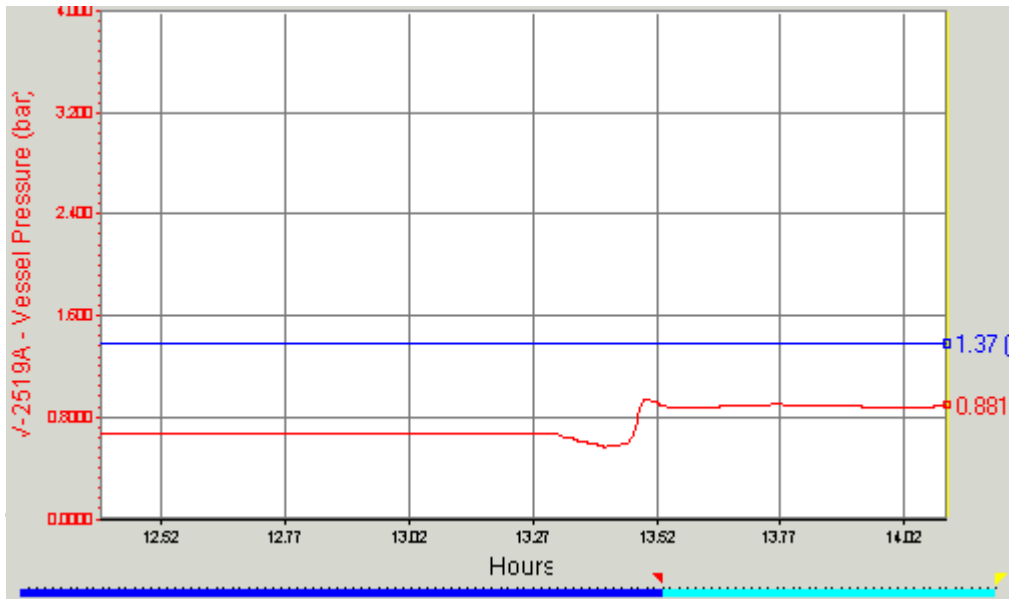


Figure 5.6.15 Pressure profile at V-2519 at the case 3.



e

5.6.16 Temperature profile at V-2519 at the case 3.

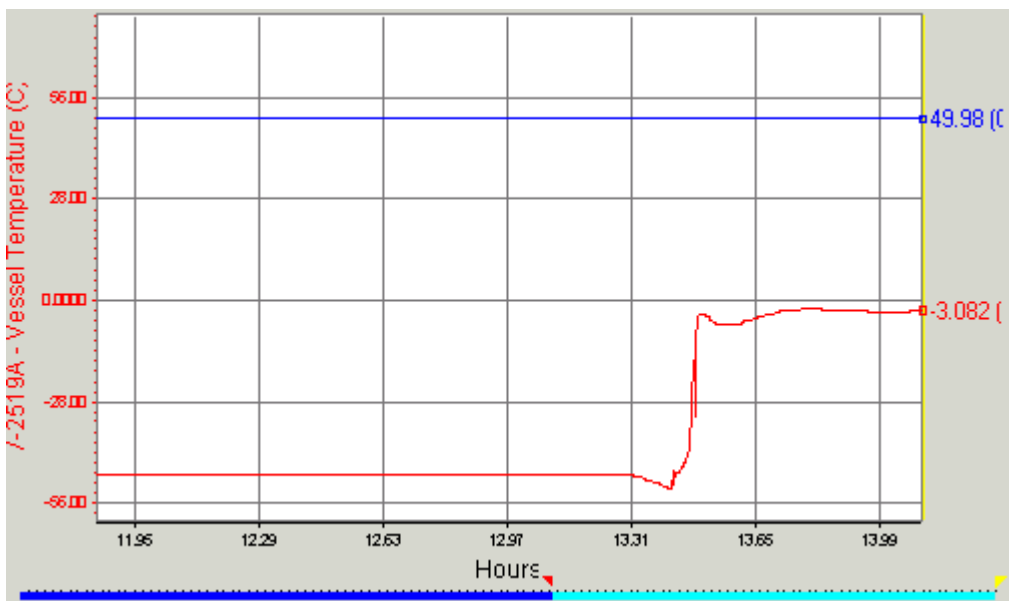


Figure 5.6.17 Pressure profile at V-2520 at the case 3.

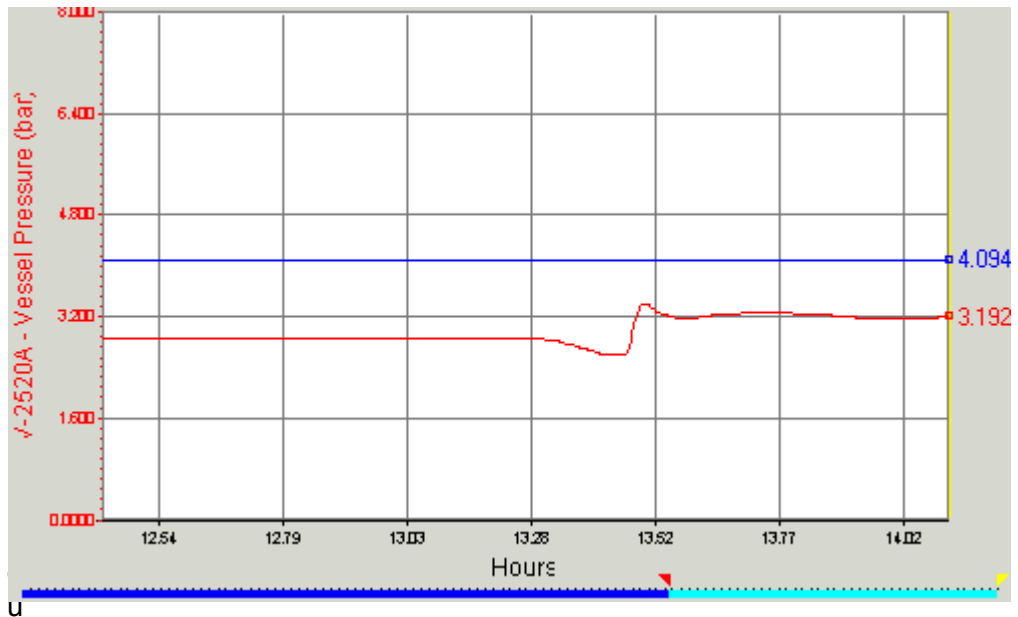


Figure 5.6.18 Temperature profile at V-2520 at the case 3.

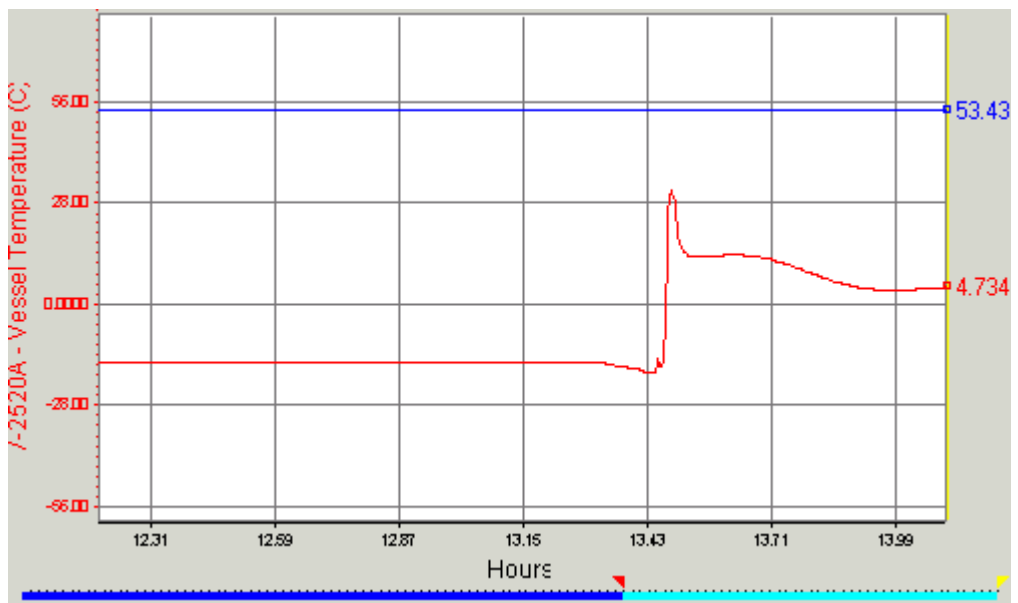


Figure 5.6.19 Opening % profile of the anti-surge valve for 1st and 2nd stage

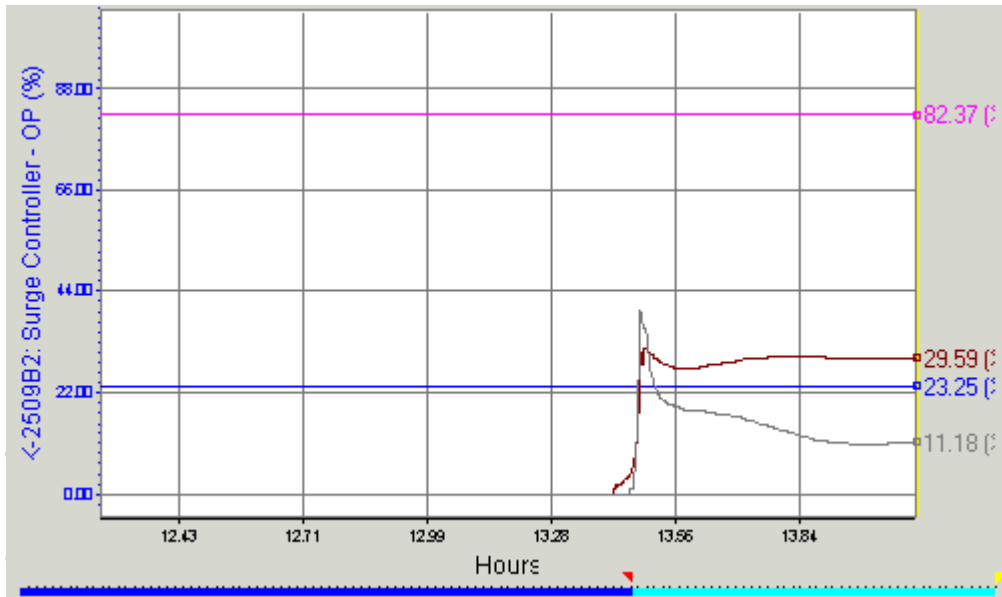


Figure 5.6.20 Pressure profile of the refrigerating system at the case 3.

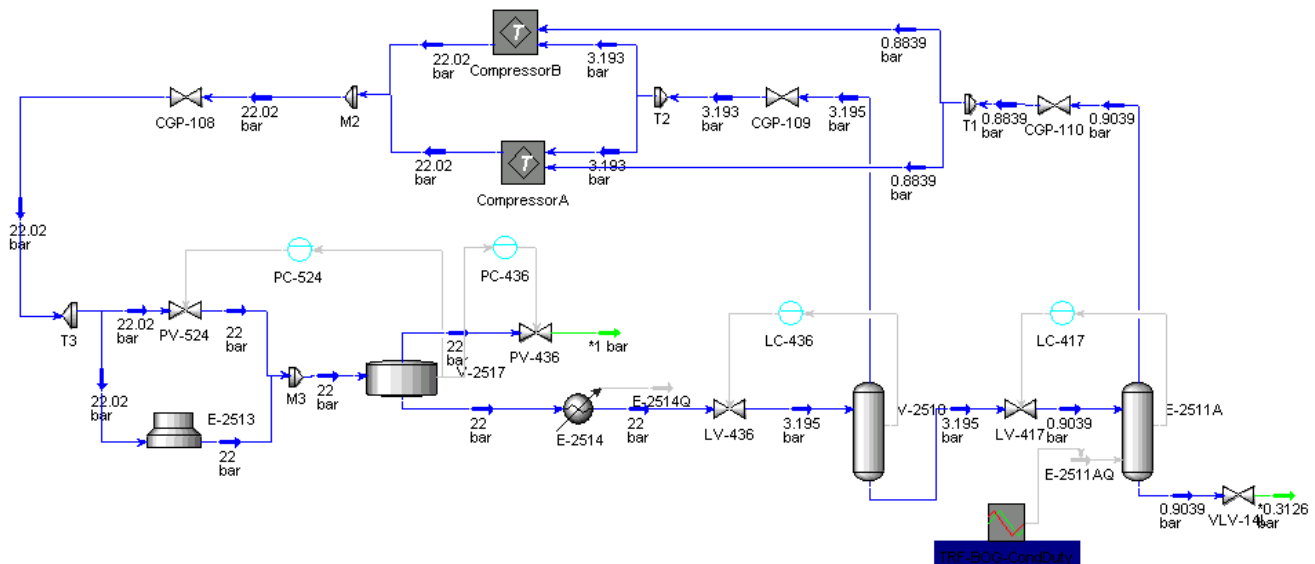


Figure 5.6.21 Temperature profile of the refrigerating system at the case 3.

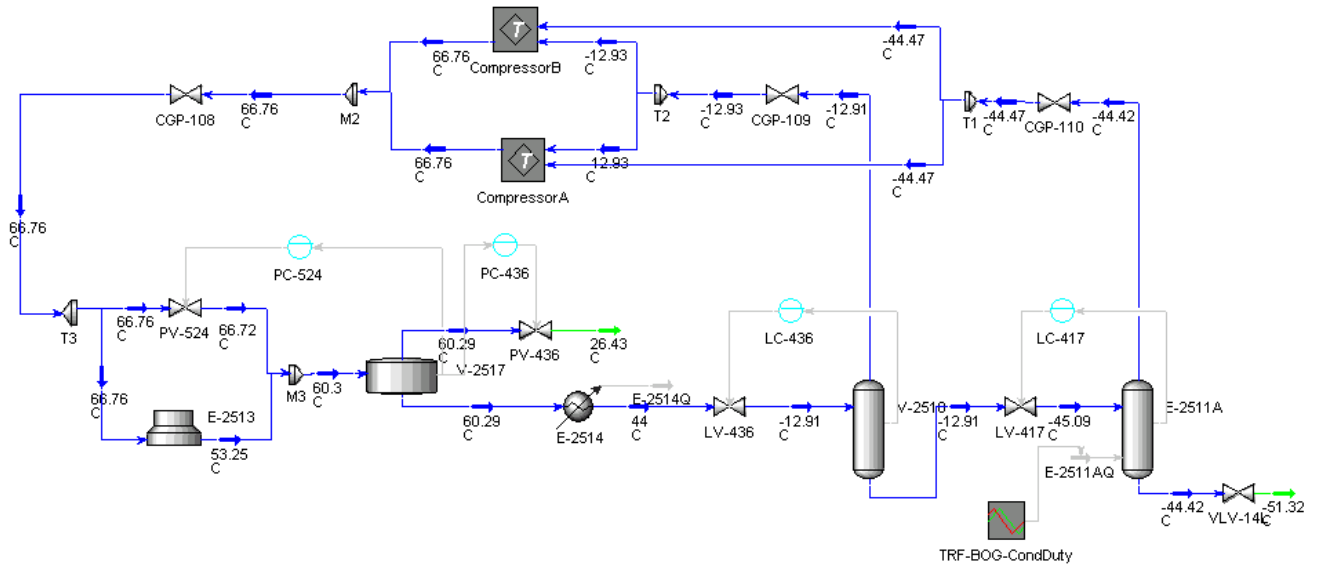
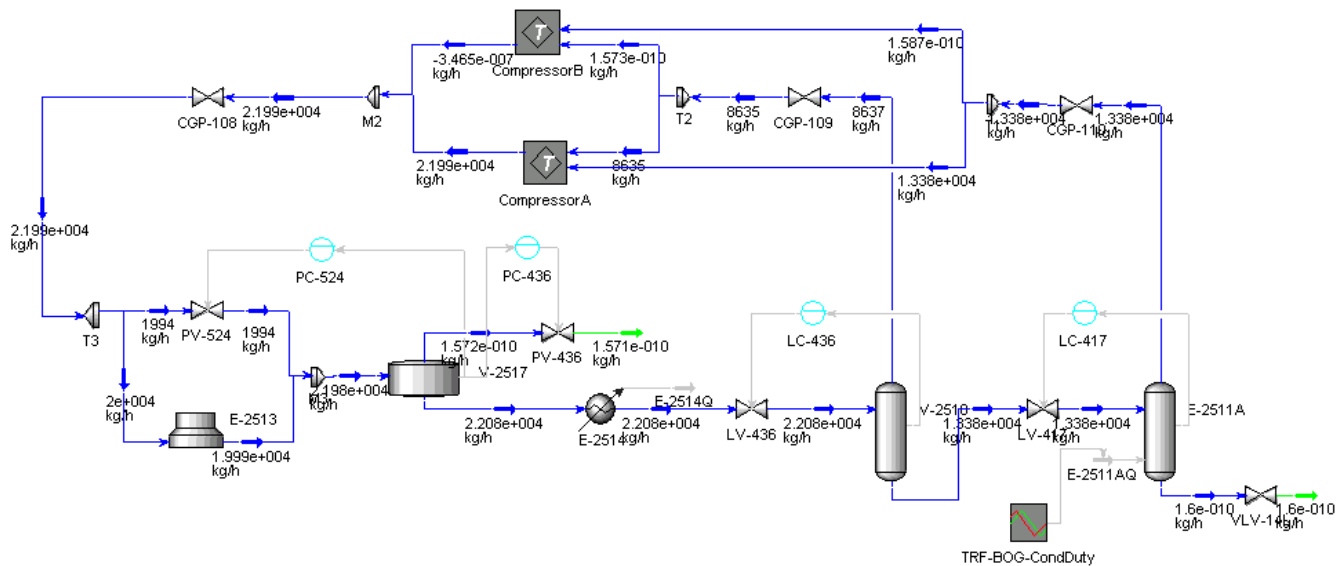


Figure 5.6.22 Mass flow rate profile of the refrigerating system at the case 3.



5.6.4 MINIMUM BOIL OFF AT MINIMUM AMBIENT TEMPERATURE (12 °C, CASE 4).

BOG condensing duty changes from 2748 KW to 556 KW. The behaviors of the refrigerating compressor system in this case are shown as follows.

Figure 5.6.23 Pressure profile at the discharge of 2nd stage at the case 4.

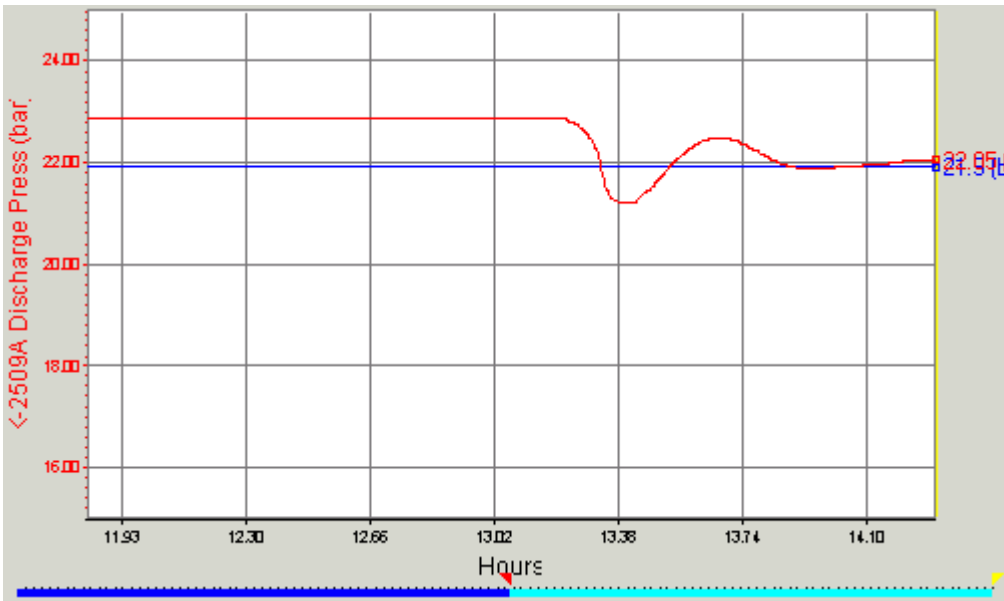


Figure 5.6.24 Temperature profile at the discharge of 2nd stage at the case 4.

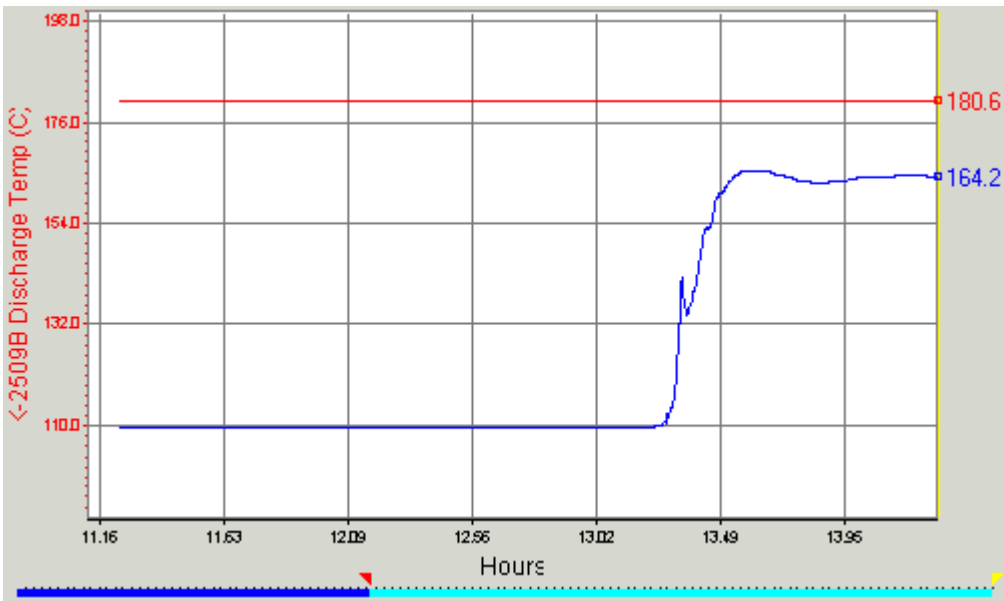
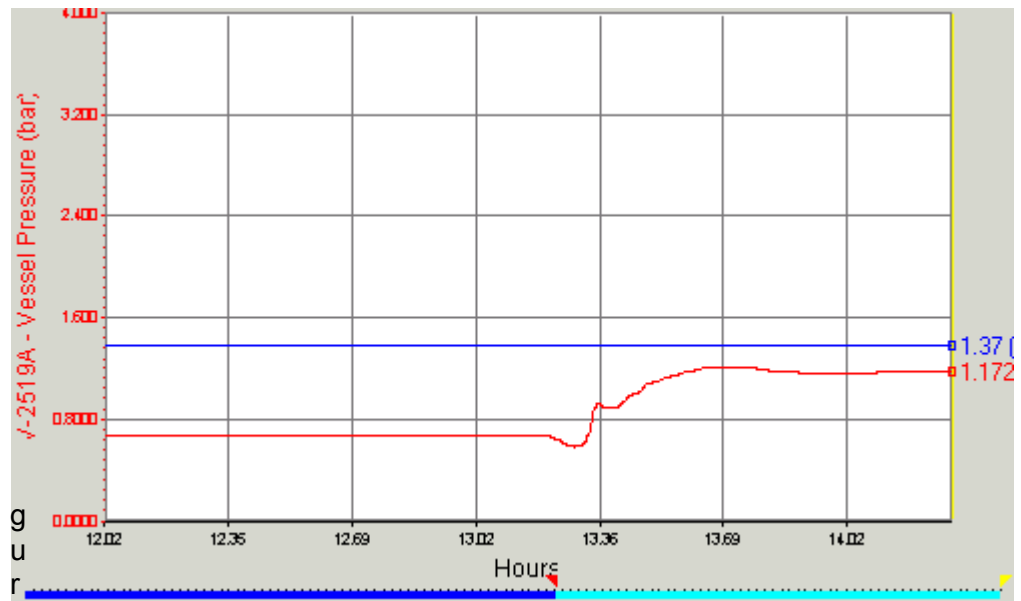
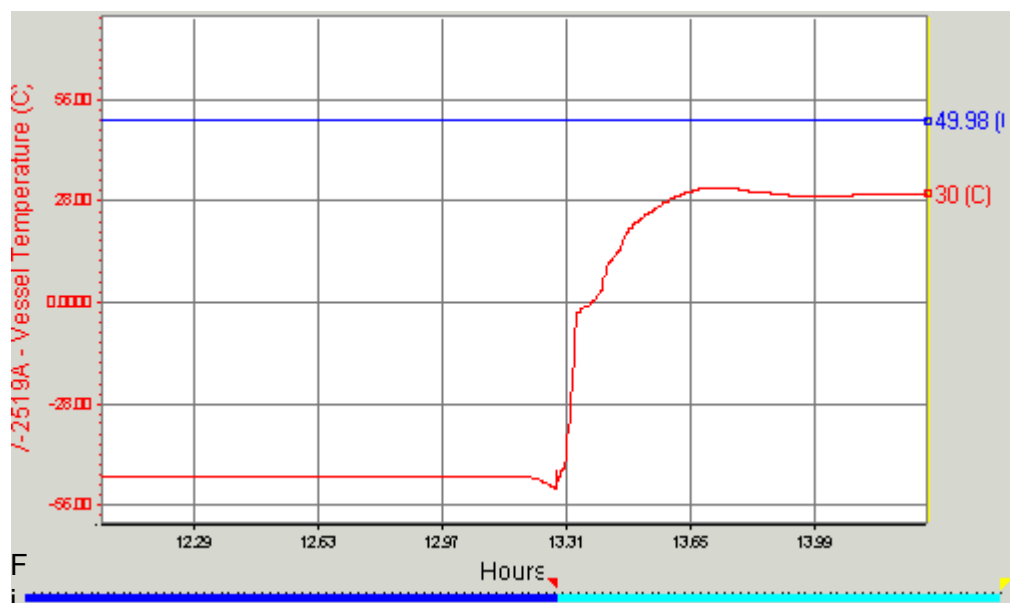


Figure 5.6.25 Pressure profile at V-2519 at the case 4.



e

5.6.26 Temperature profile at V-2519 at the case 4.



F

Figure 5.6.27 Pressure profile at V-2520 at the case 4.

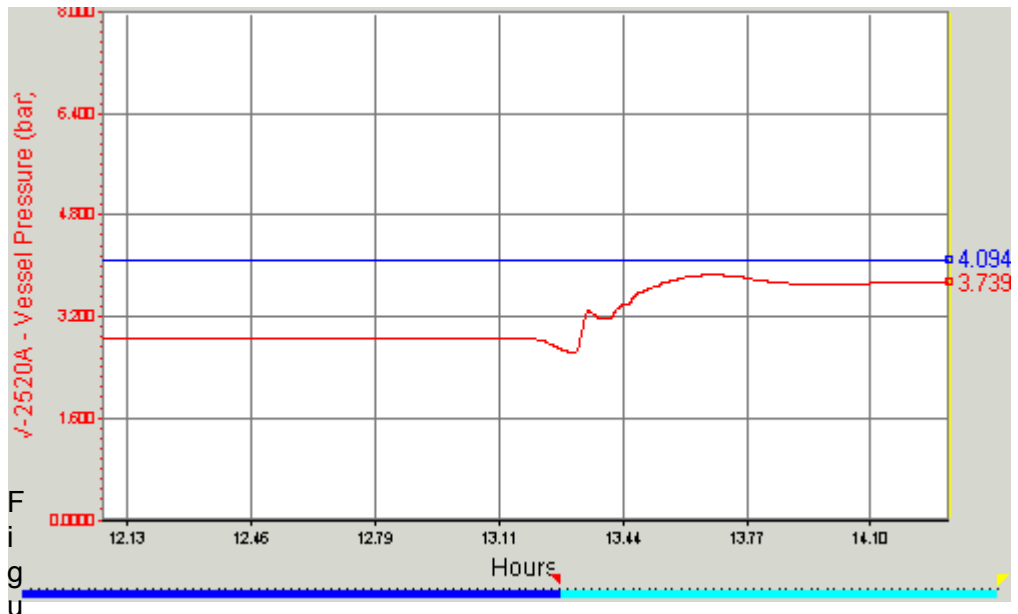


Figure 5.6.28 Temperature profile at V-2520 at the case 4.

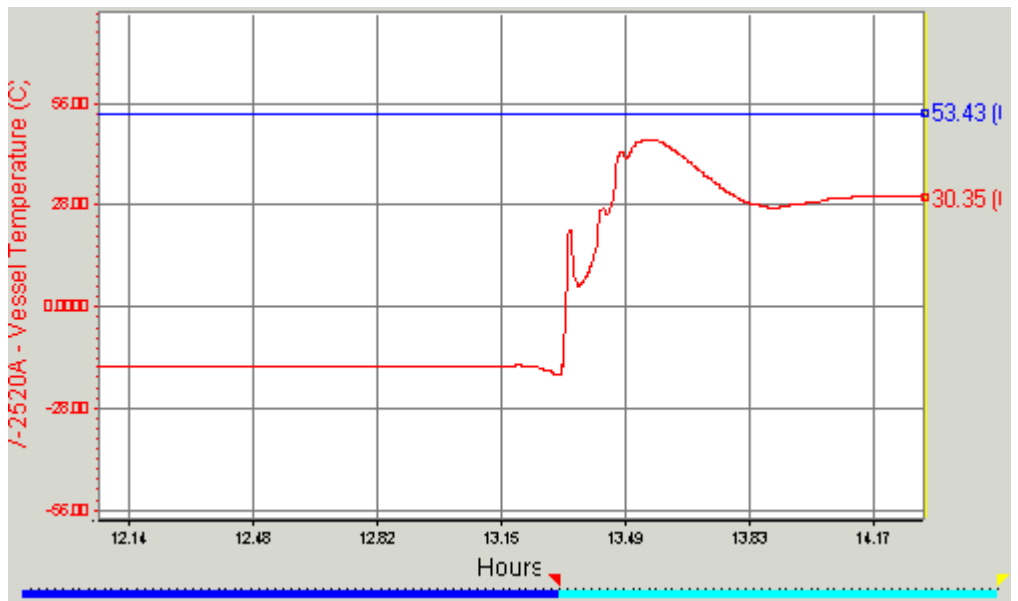


Figure 5.6.29 Opening % profile of the anti-surge valve for 1st and 2nd stage

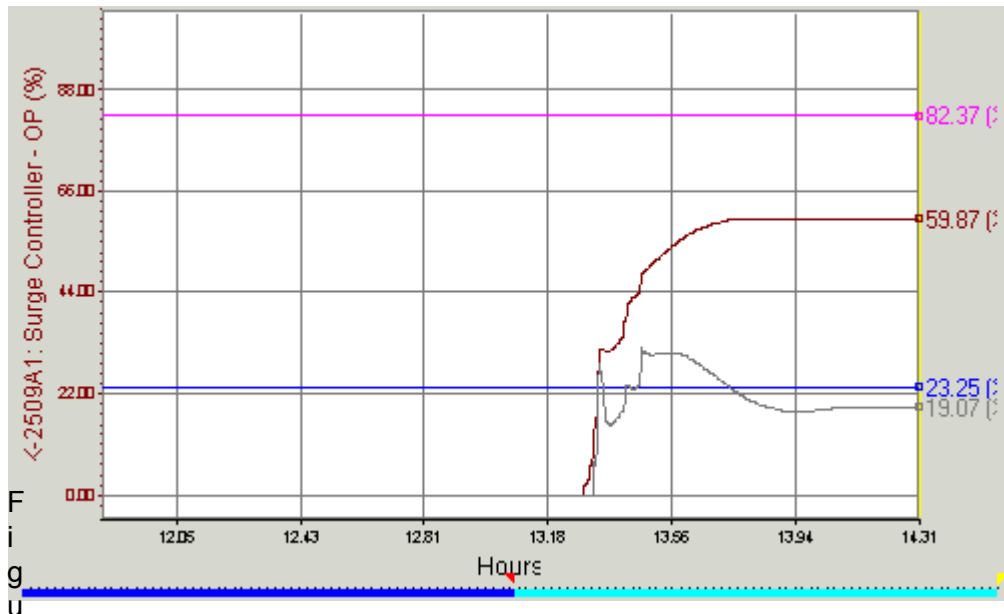


Figure 5.6.30 Pressure profile of the refrigerating system at the case 4.

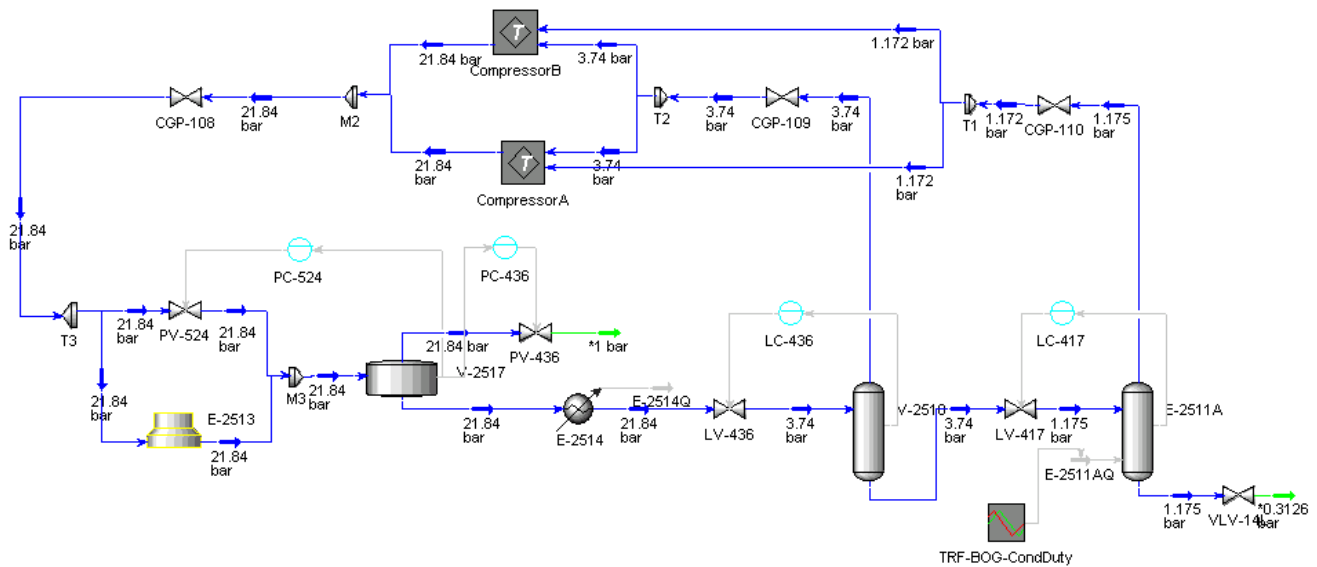


Figure 5.6.31 Temperature profile of the refrigerating system at the case 4.

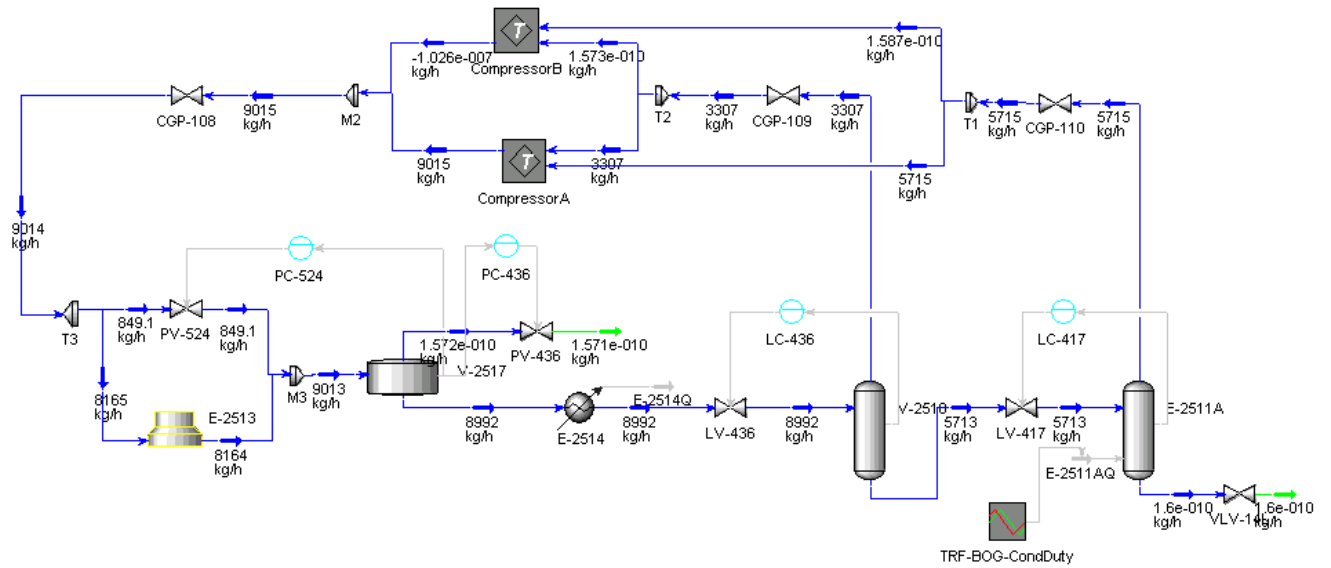
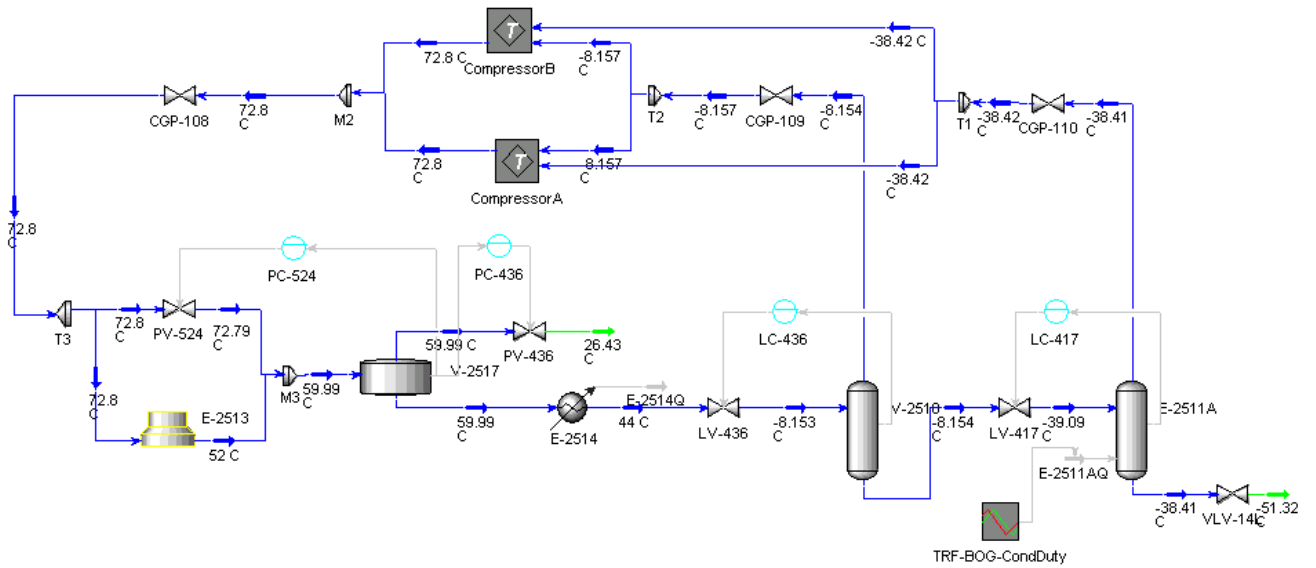


Figure 5.6.32 Mass flowrate profile of the refrigerating system at the case 4.



5.7 CASE STUDY FOR ALL POSSIBLE CHANGES

The purpose of this simulation study is to cover all possible mode changes in the refrigerating compressor system. The scenario and results are as follows.

- First, mode change to from 52 °C Holding Mode to 12 °C Holding Mode
- After 1 hr, mode change to from 12 °C Holding Mode to 12 °C Loading Mode
- After 1 hr, mode change to from 12 °C Loading Mode to 52°C Loading Mode
- After 1 hr, mode change to from 52 °C Loading Mode to 12°C Loading Mode
- After 1 hr, mode change to from 12 °C Loading Mode to 12°C Holding Mode
- After 1 hr, mode change to from 12 °C Holding Mode to 52°C Holding Mode

Figure 5.7.1 Pressure profile at the discharge of 2nd stage at the all cases

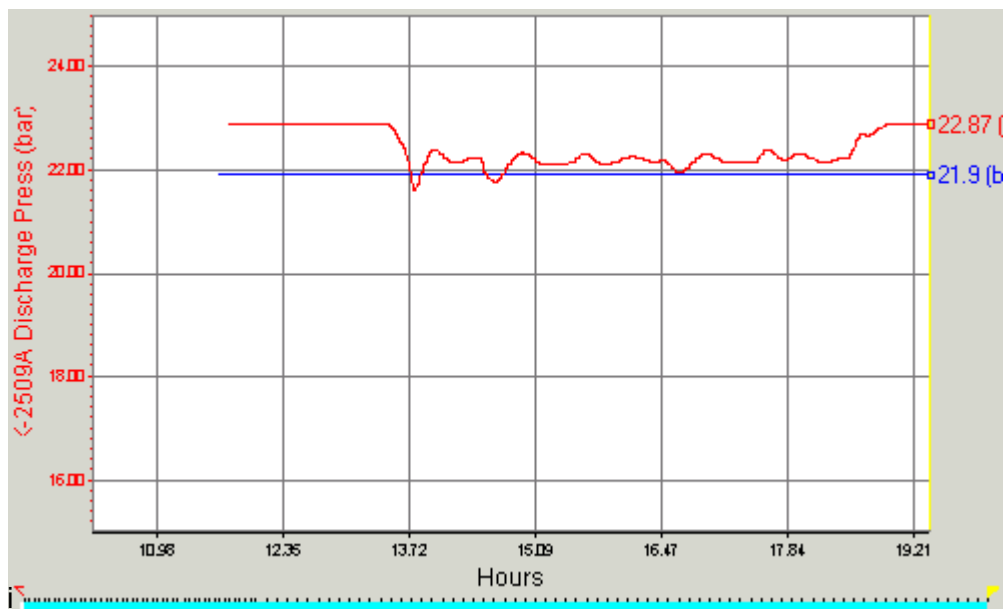


Figure 5.7.2 Temperature profile at the discharge of 2nd stage at the all cases

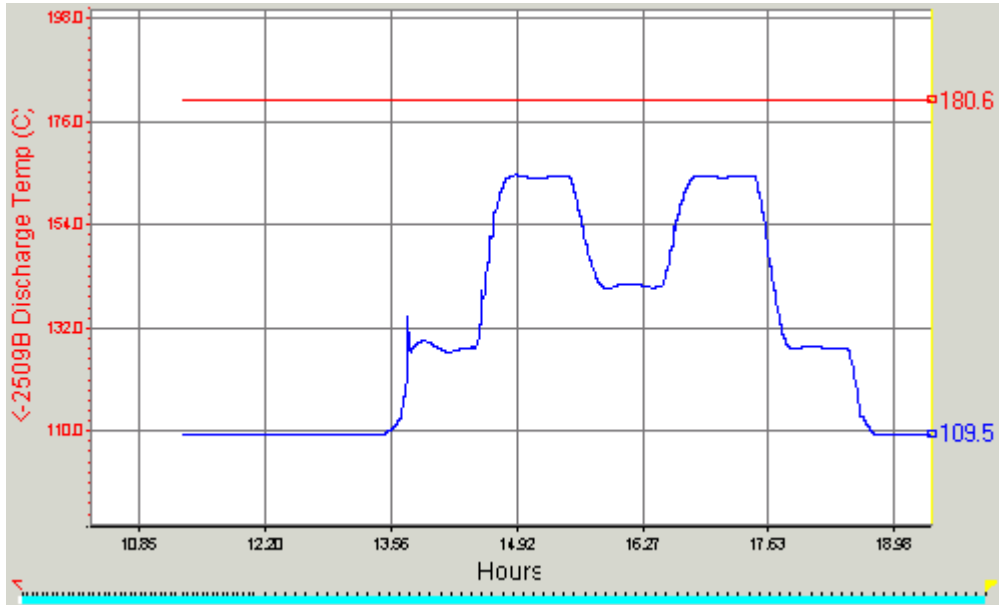


Figure 5.7.3 Pressure profile of the V-2519 at the all cases

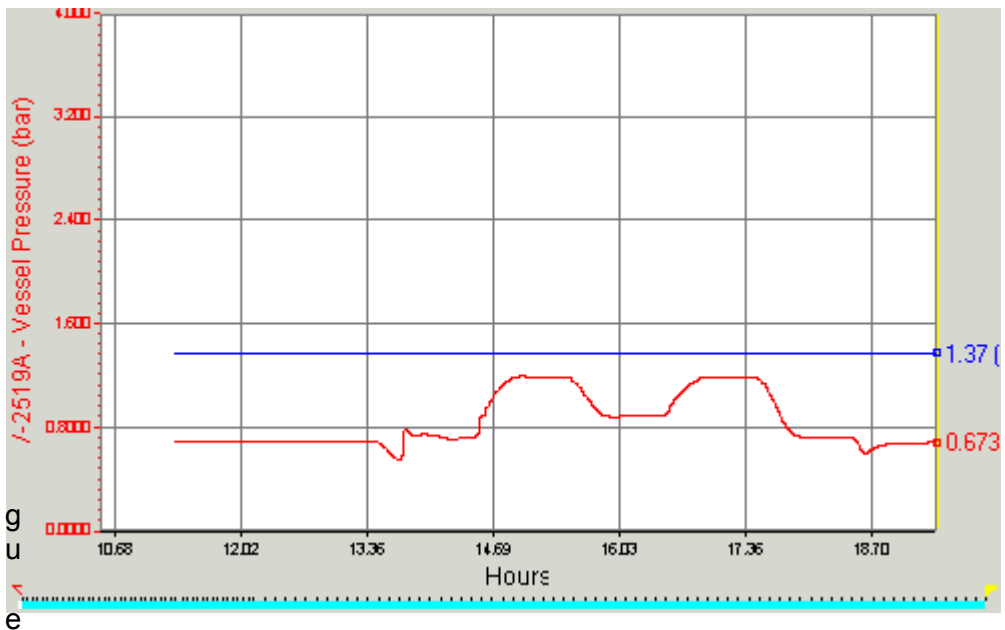


Figure 5.7.4 Temperature profile of the V-2519 at the all cases

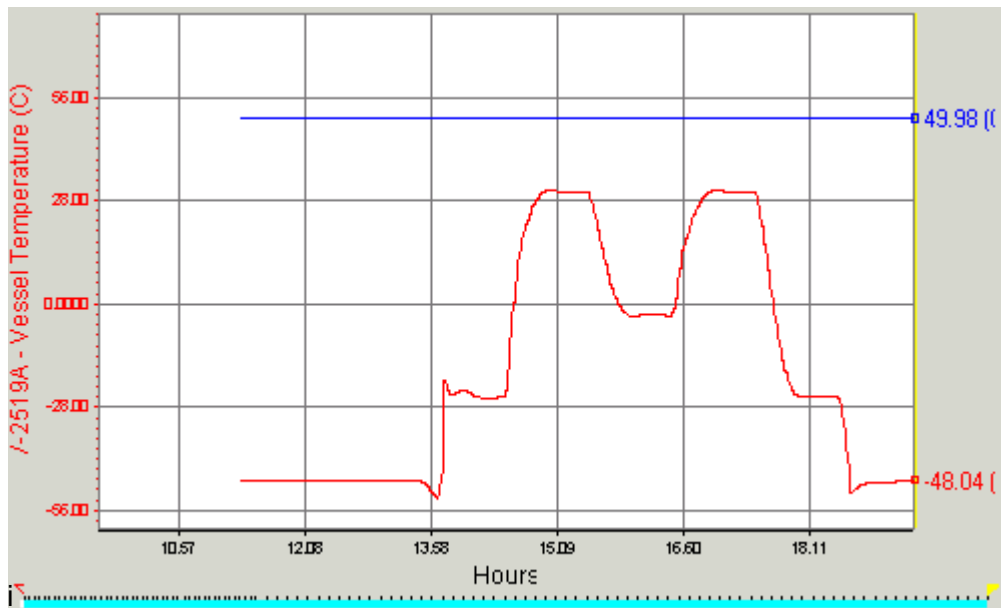


Figure 5.7.5 Pressure profile of the V-2520 at the all cases

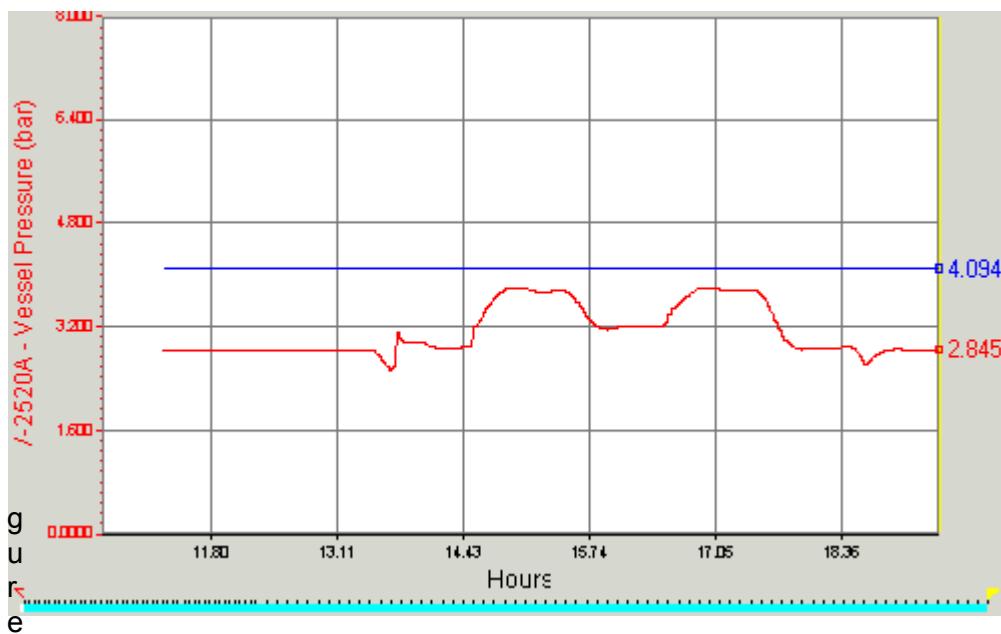


Figure 5.7.6 Temperature profile of the V-2520 at the all cases

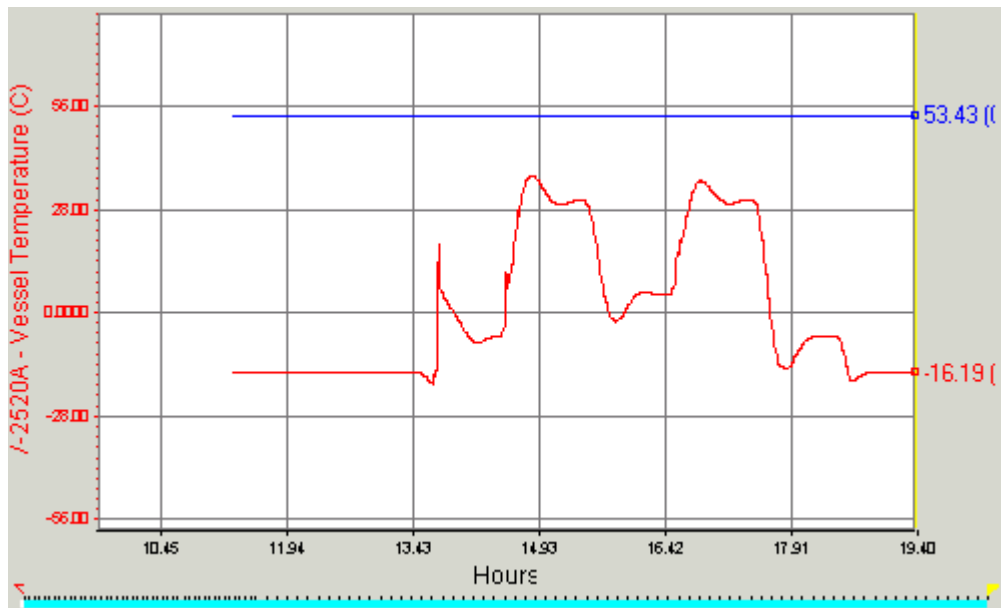
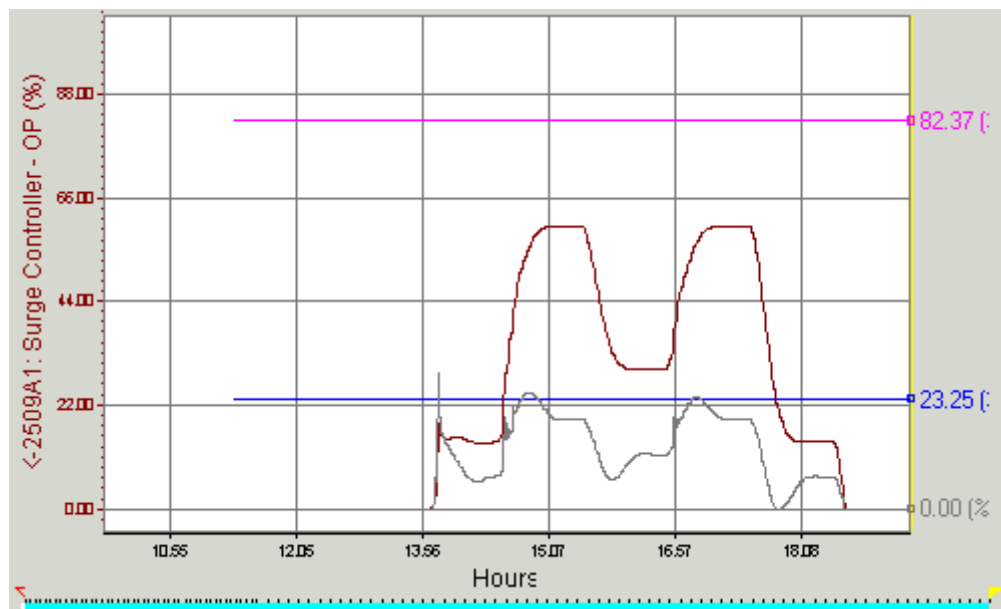


Figure 5.7.7 Opening % profile of the anti-surge valve for 1st and 2nd stage



5.8 LOAD TRANSFER AT EACH CASES

This simulation is to show that the stand-by compressor K-2509B can be replaced as K-2509A at any mode. The case for the 52 °C holding mode is already shown in the section 5.5. The results of the load transfer at other cases are shown at belows.

Figure 5.8.1 Pressure profile of the V-2519 at the 12 °C holding mode (Case 2)

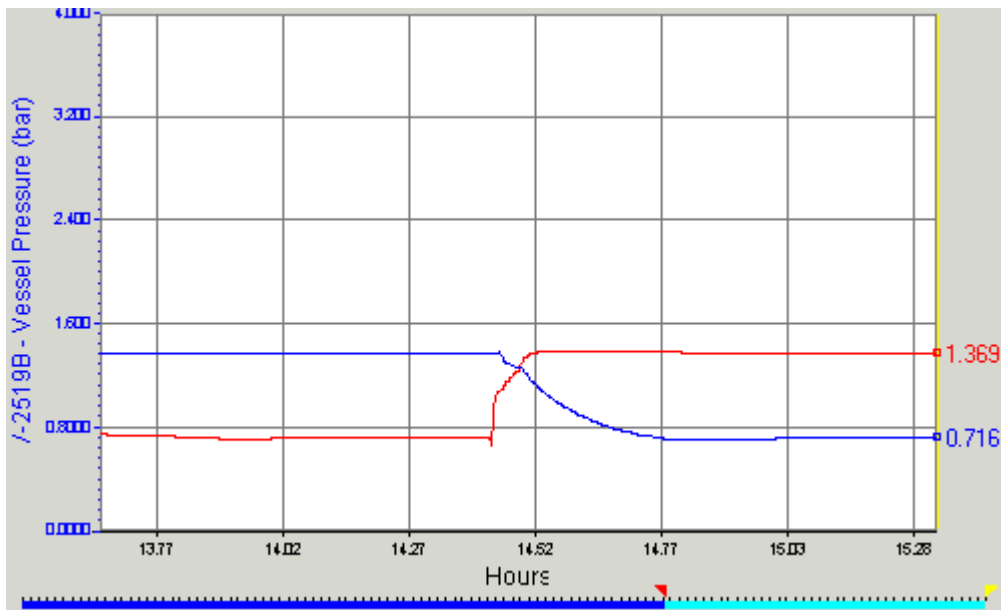


Figure 5.8.2 Pressure profile of the V-2519 at the 52 °C loading mode (Case 3)

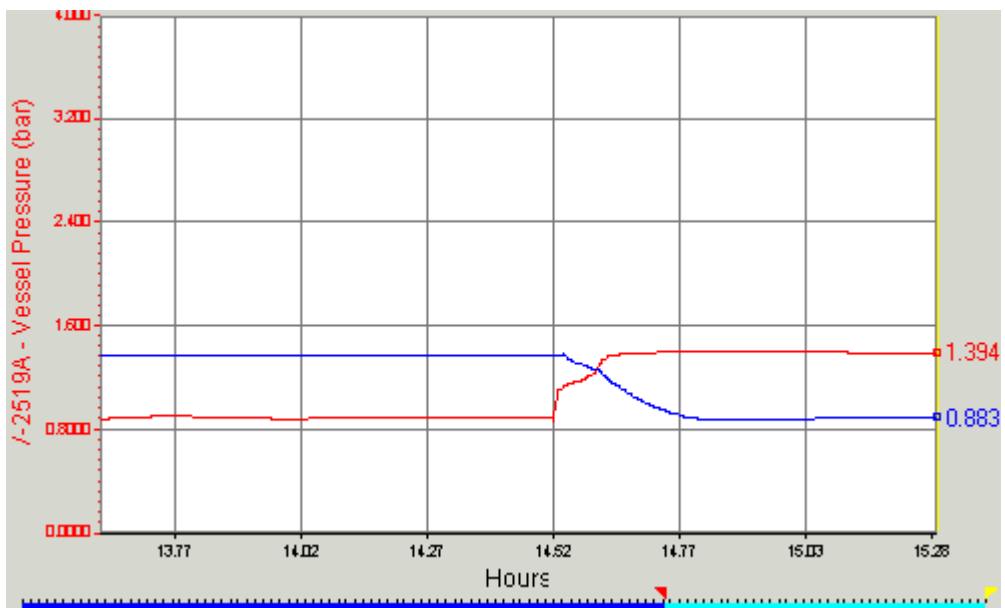


Figure 5.8.3 Pressure profile of the V-2519 at the 12 °C loading mode (Case 4)

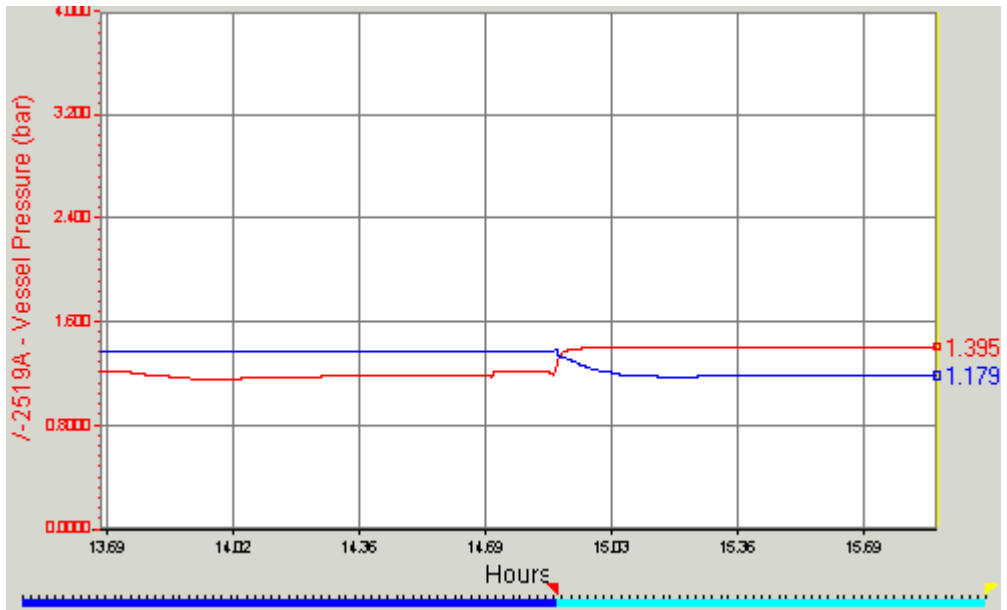


Figure 5.8.4 Temperature profile of the V-2519 at the 12 °C holding mode (Case 2)

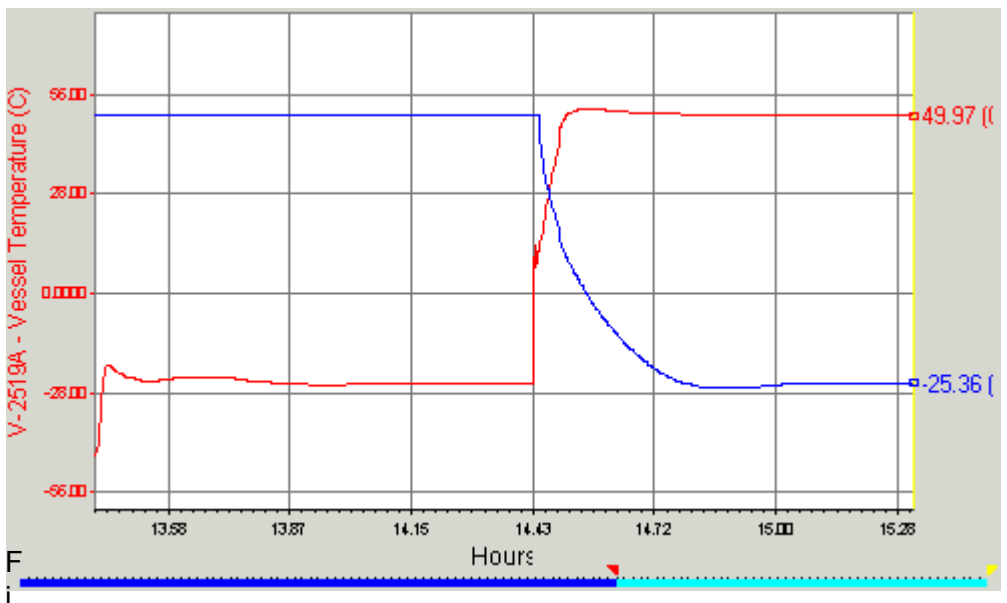


Figure 5.8.5 Temperature profile of the V-2519 at the 52 °C loading mode (Case 3)

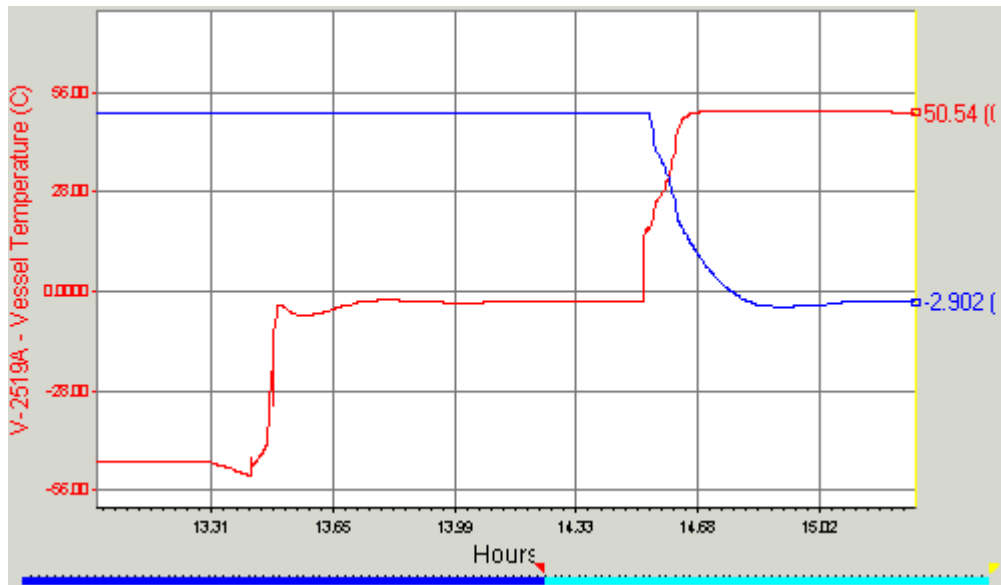


Figure 5.8.7 Temperature profile of the V-2519 at the 12 °C loading mode (Case 4)

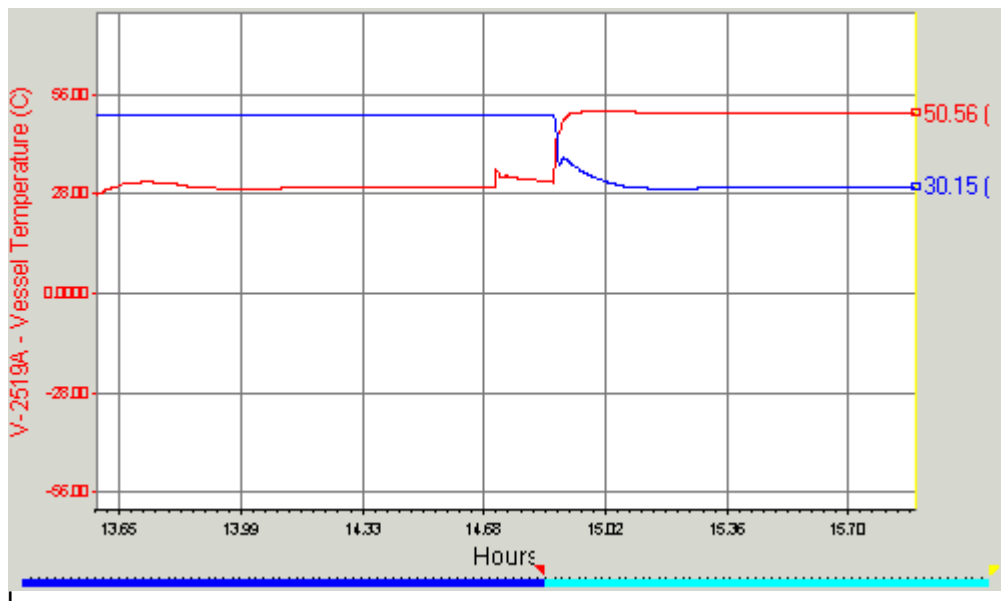


Figure 5.8.8 Pressure profile of the V-2520 at the 12 °C holding mode (Case 2)

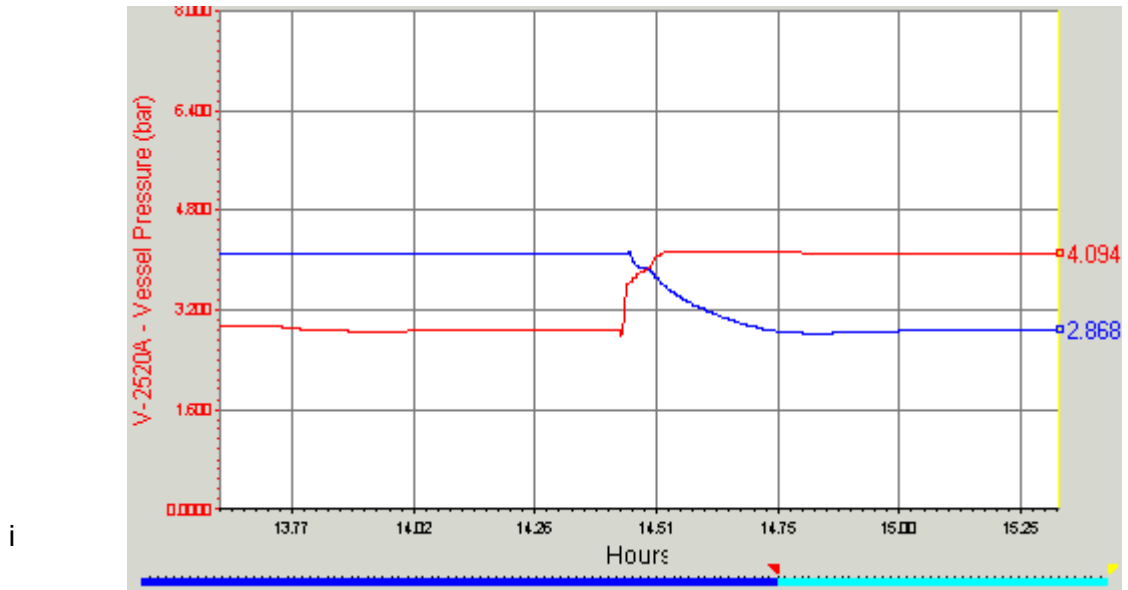


Figure 5.8.9 Pressure profile of the V-2520 at the 52 °C loading mode (Case 3)

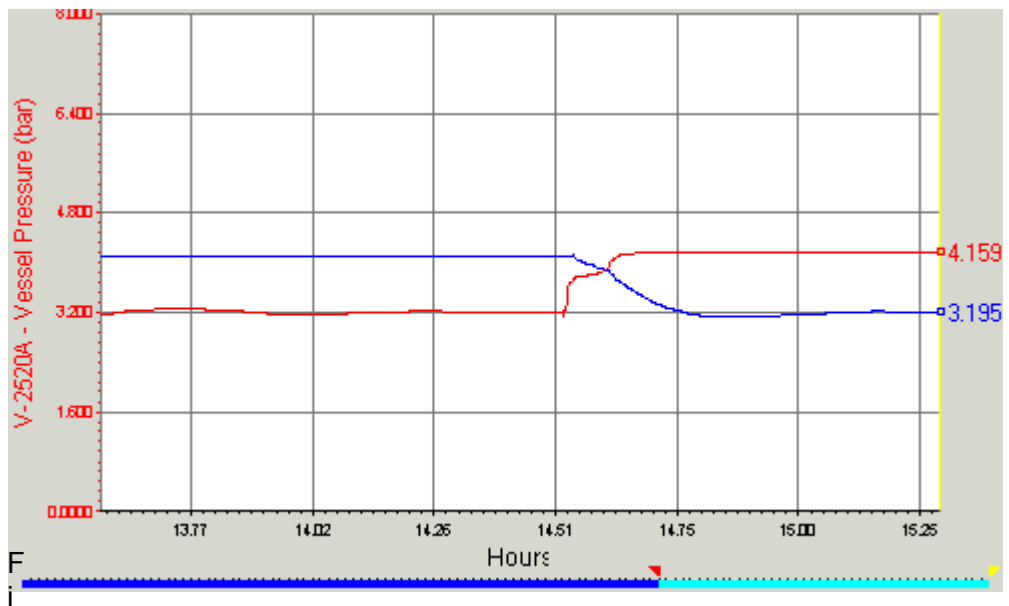


Figure 5.8.10 Pressure profile of the V-2520 at the 12 °C loading mode (Case 4)

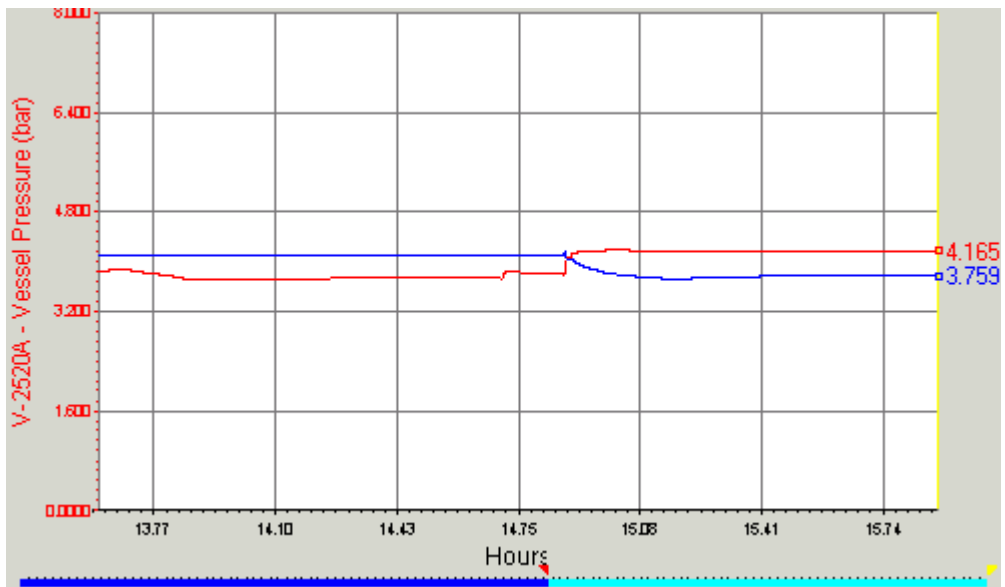
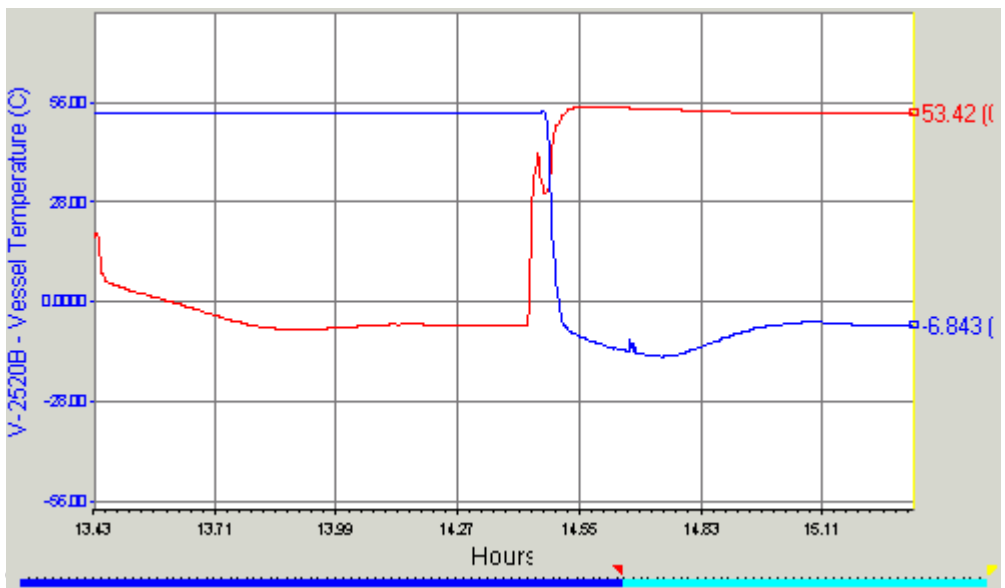


Figure 5.8.11 Temperature profile of the V-2520 at the 12 °C holding mode (Case 2)



U

Figure 5.8.12 Temperature profile of the V-2520 at the 52 °C loading mode (Case 3)

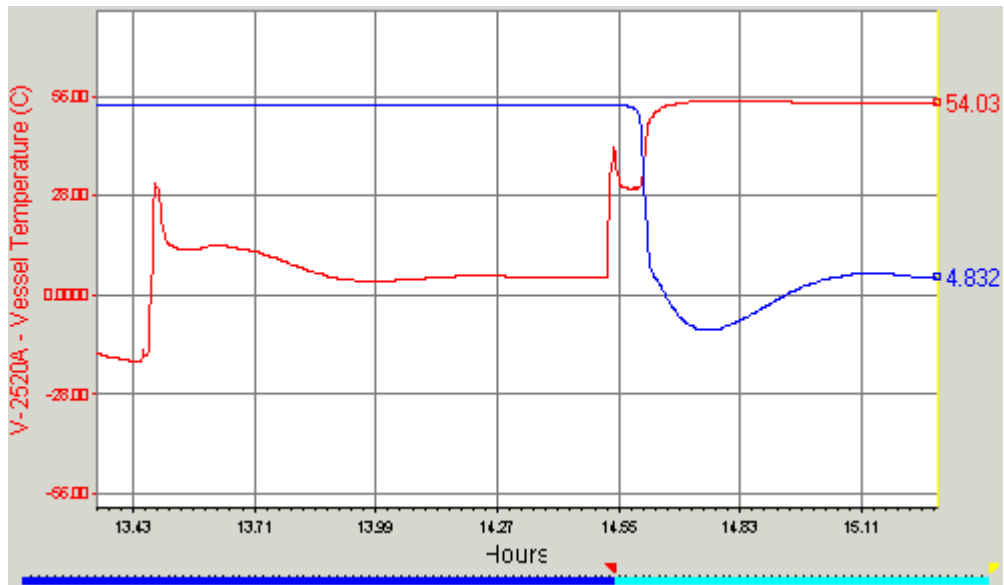
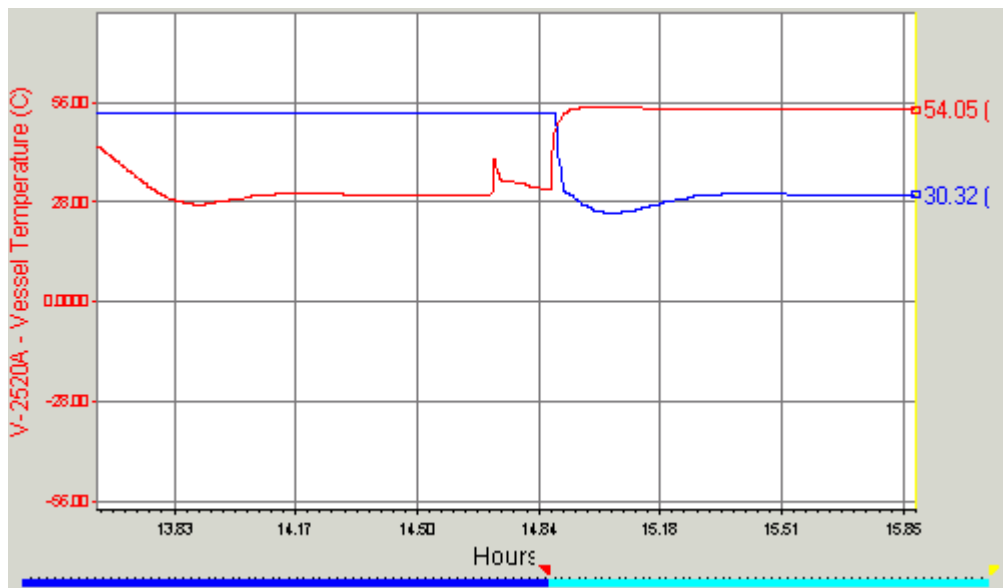


Figure 5.8.13 Temperature profile of the V-2520 at the 12 °C loading mode (Case 4)



g

Figure 5.8.15 Opening % profile of the anti-surge valve at the 12 °C holding mode (Case 2)

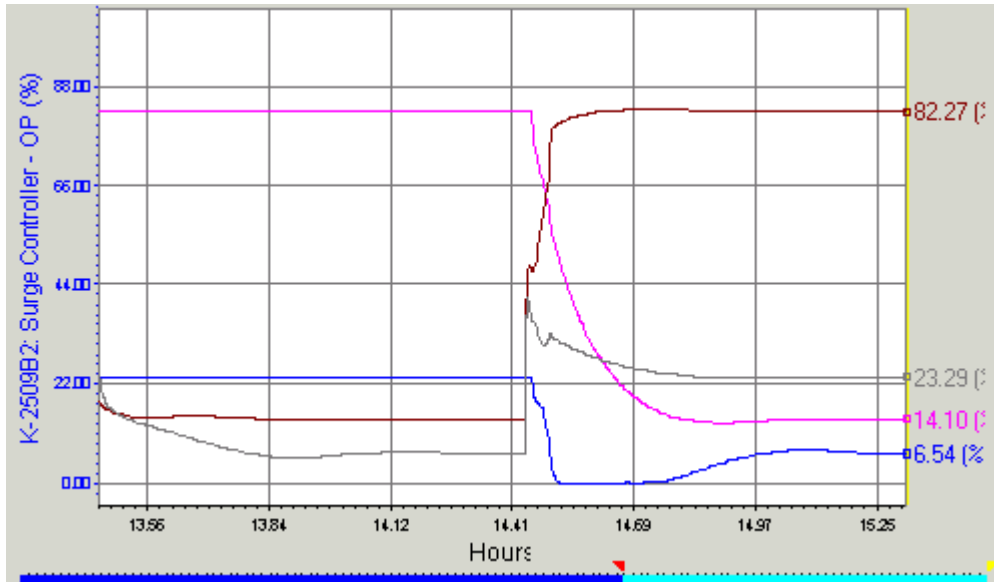
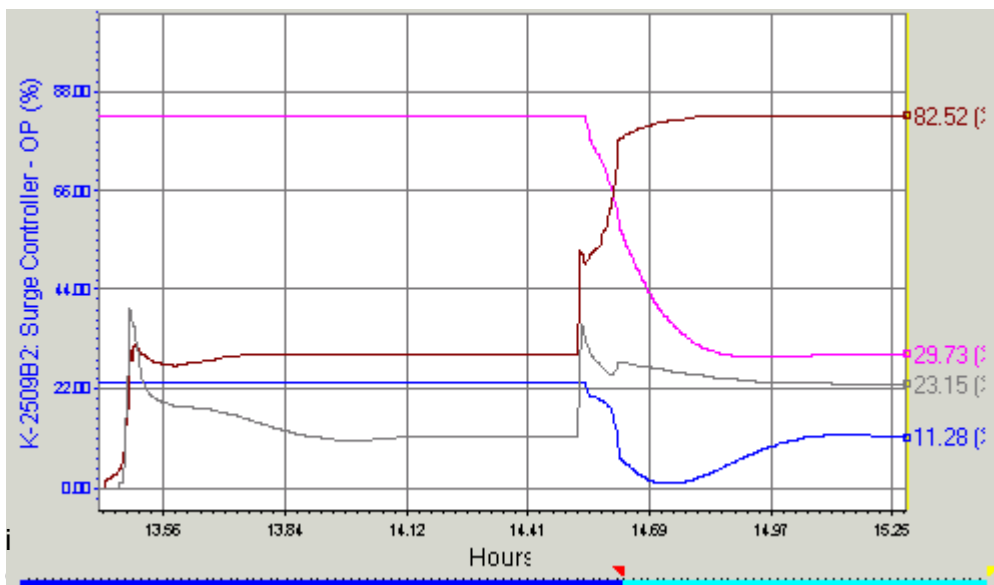
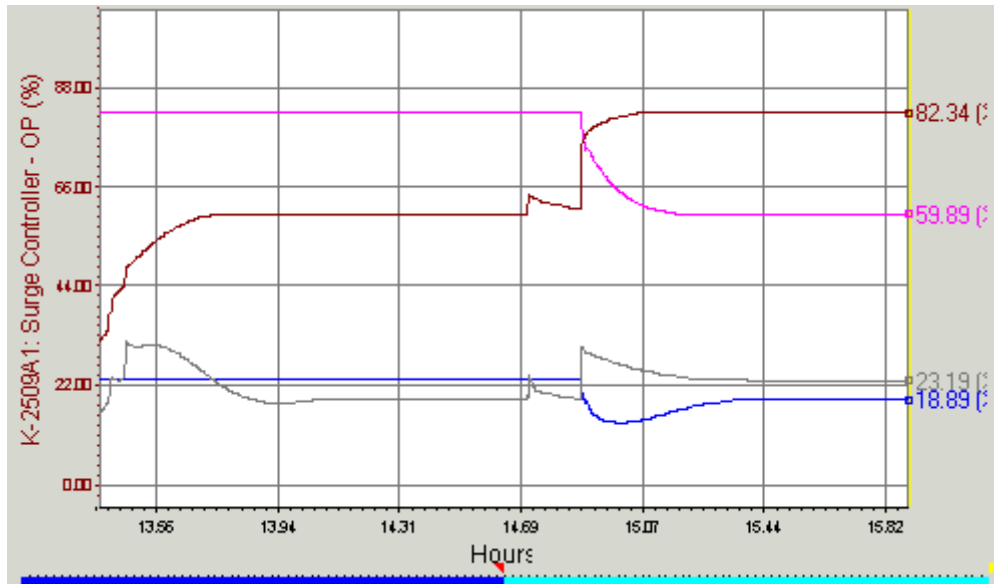


Figure 5.8.16 Opening % profile of the anti-surge valve at the 52 °C loading mode (Case 3)



U

Figure 5.8.7 Opening % profile of the anti-surge valve at the 12 °C loading mode (Case 4)



5.9 SETTLE OUT CASE WITH LIQUID FILLED SURGE DRUM

This case is to see the settle out pressure of propane refrigeration compressor system when the suction drums (V-2519, V-2520) are not empty and filled with propane condensing liquid at 500 mm level. The settle out pressure is lower than the previous case in which there is no liquid in the suction drums. It is due to the vaporization of liquid that reduces the settle out. **The effect of heat-in leak from surroundings will be ignored because it will take a long time compared with the pressure settling time**

The results are as follows.

Figure 5.9.1 Pressure profile of the V-2519 at settling with liquid filled surge drum

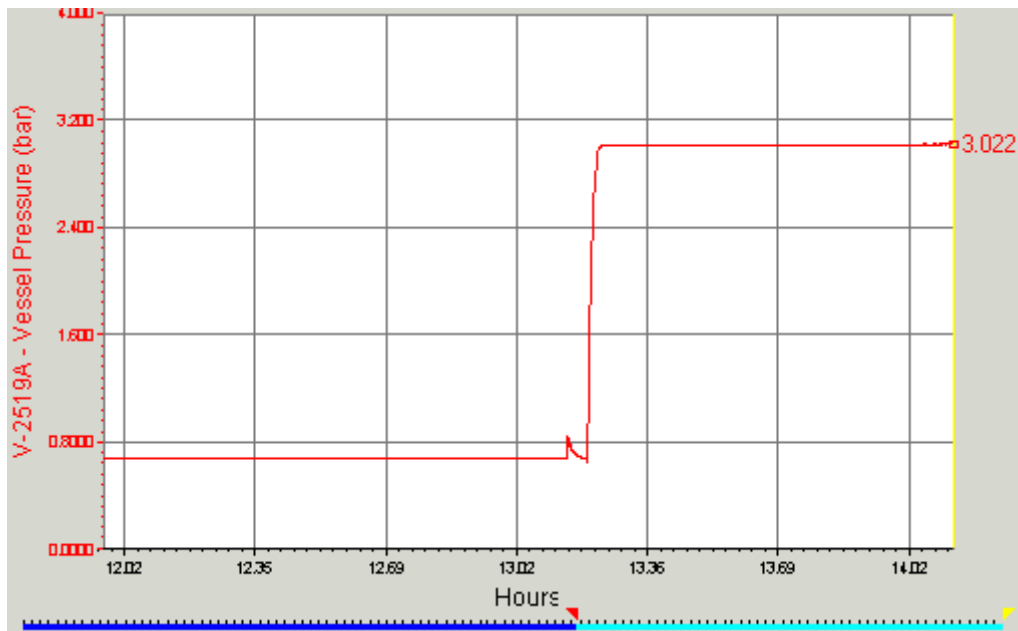


Figure 5.9.2 Temperature profile of the V-2519 at settling with liquid filled surge drum

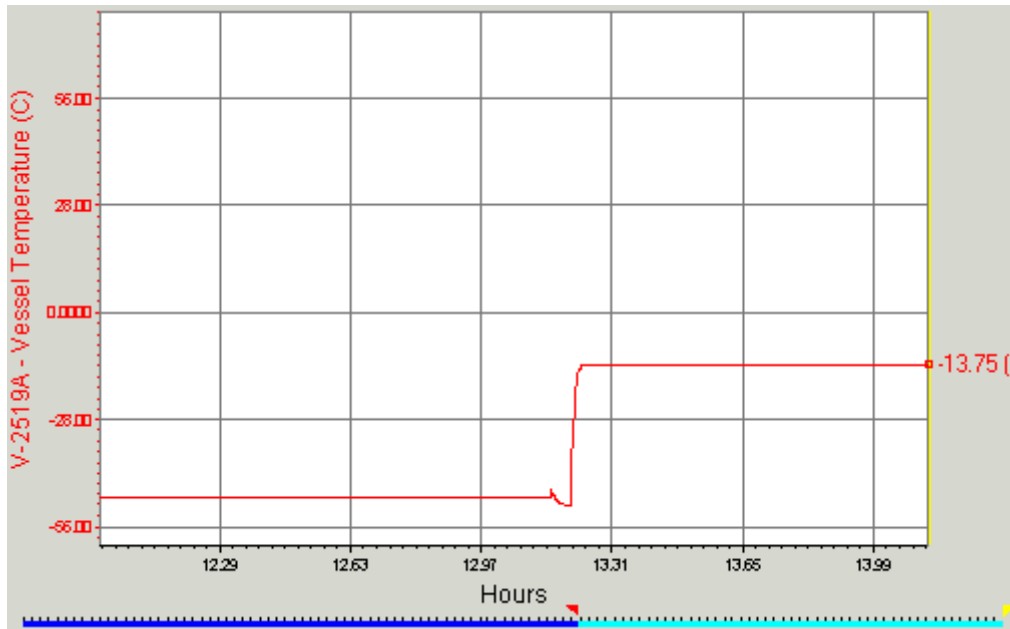


Figure 5.9.3 Pressure profile of the V-2520 at settling with liquid filled surge drum

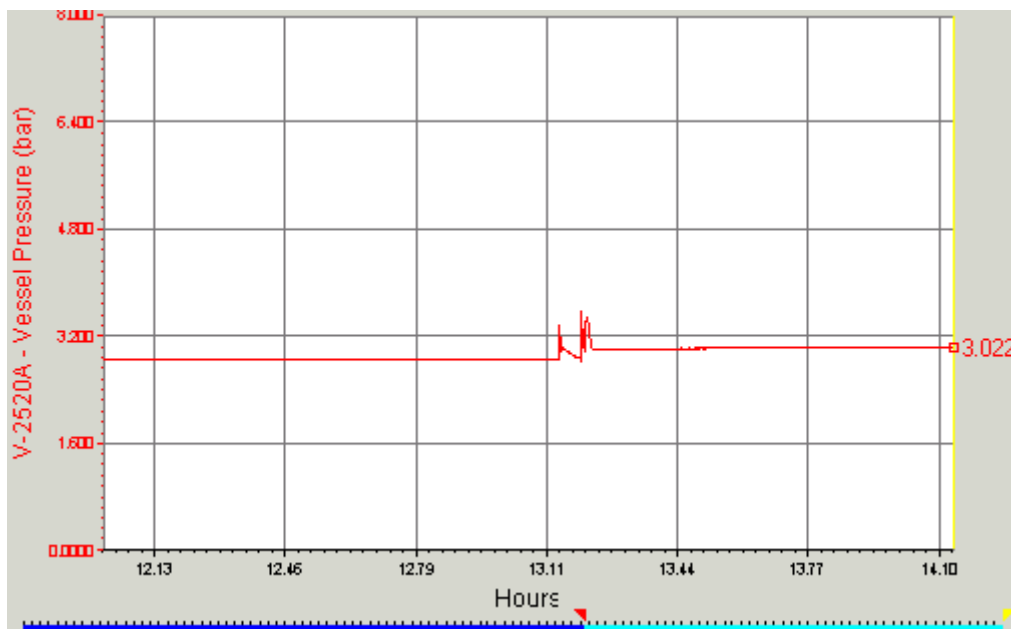


Figure 5.9.4 Temperature profile of the V-2520 at settling with liquid filled surge drum

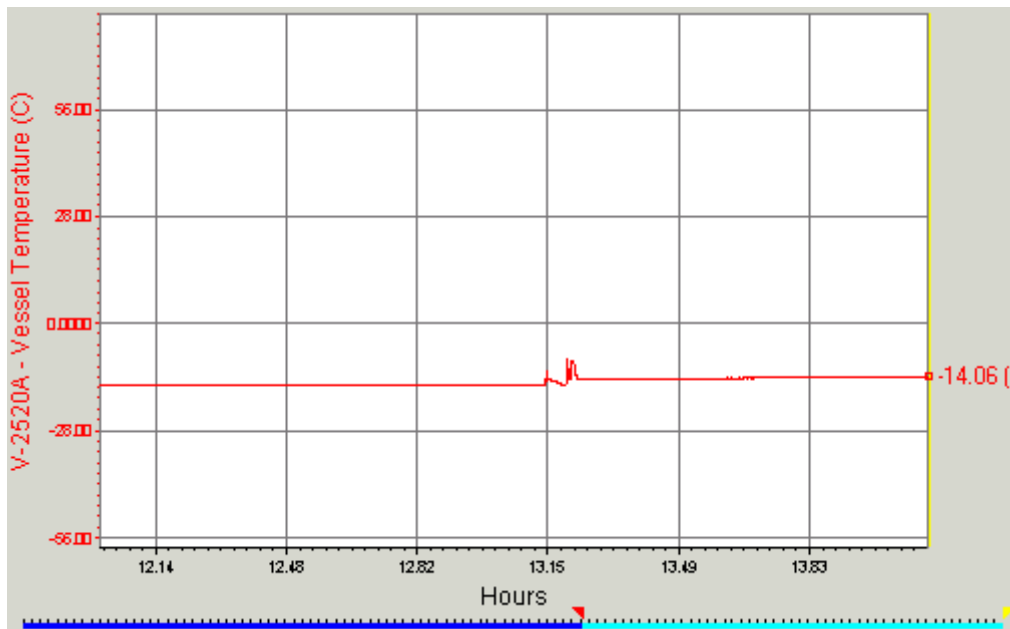


Figure 5.9.5 Level profile of the V-2519/V-2520 at settling with liquid filled surge drum

